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***The following Original Articles will appear in our next issue
(March 1924).***

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F.Z.S.; and C. M. Inglis,
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Original Articles

SOME COMMON INDIAN BIRDS.

No. 25. THE GREEN BARBET (*THEREICERYX ZEYLANICUS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist :

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

ALTHOUGH common enough where it occurs, the Green Barbet is not found in the less wooded areas of the country, such as the Punjab and Sind, Rajputana and the more open parts of the Deccan and Carnatic. In areas where it does occur, however, it is sufficiently a common bird to merit inclusion in our list, especially as its call is probably more familiar than its personal appearance. It is a thick-set bird, about as large as a mynah, with a thick, heavy bill, in colour of a bright leaf-green with a brownish head and a bare brown patch around the eye; but, as it always keeps near the tree-tops, it is less often seen than heard. Sometimes it may be seen on the wing, when its flight is strong but rather heavy and undulating. Its call is loud and monotonous, but by no means harsh or discordant, and is usually written *tur-t-r-r*, *kutur*, *kutur*, *kutur*, the call being indicated in the various vernacular names, such as *Kotur* (Hindustani), *Kuturga* (Maharatti), *Kotoruwa* (Sinhalese) and *Katur* (Tamil). The call often sounds much like the word *Pakrao*, repeated several times.

Like most other birds, however, this Barbet is not confined to the use of a single note. In this connection Stuart Baker, in his

"Birds of North Cachar," writing about a very similar and closely allied bird, the Assam Lineated Barbet (*Thereciopoda lineatus hodgei*) makes the following interesting remarks: "I have heard this bird labelled as being a bird of one note; now any one who has listened to it *carefully* must admit that it has many. Whilst feeding, it has a large variety of sounds at its disposal. When pleased, it utters a sort of hoarse 'chortle'; but, to make this sound, it seems to be necessary to be on the move, for it always utters it when hopping from one branch to another, or else it gives a little jerk into the air at the same time that it opens its mouth to give vent to its feelings. Displeasure, which seems to be caused chiefly by seeing other birds feeding with it, is expressed by a ridiculously feeble little sound like 'pénch, pénch,' the feebleness being made up for, to some extent, by the bird's ferocious attitude as he advances, with drooping wings and mouth wide open, towards the object of his displeasure. The most unusual note is one it makes use of only in the cold weather, at which time these birds sometimes collect in small flocks, and only in the mornings and evenings, seemingly for the purpose of collecting any scattered individuals. It consists of a loud clear whistle, a most wild and penetrating sound, but at the same time rather musical than otherwise. It is an abnormal sort of a sound for a barbet to give utterance to and had I not followed up and shot some of these birds whilst actually whistling thus, I should never have imagined what had made the sound." The Green Barbet may sometimes be heard calling at night, especially on moonlit nights.

Like other Indian Barbets, this bird lives chiefly on fruit. The late Mr. C. W. Mason examined the stomachs of fifteen birds at Pusa and found nothing but wild fig fruits in them. It is very fond of *Lantana* berries and helps to distribute the seeds of this noxious weed. This bird, however, has a curious habit of pulling off bits of bark from trees, especially from dead branches, as if searching for insects, and Blandford states that it is said occasionally, though rarely, to eat insects. Insects, however, evidently form a very small part of its diet and from an economic point of view this bird cannot be claimed as useful.

Blanford states that the characteristic "call is heard from January or February till June," and Dewar also says that this is heard "during the latter part of the cold weather and the early part of the hot weather." Where the bird is common, however, the call may be heard throughout the year, although more persistently during the first half of the year. As I write these lines (8th November) a Green Barbet is calling at intervals in a nearby tree.

Nesting takes place in a hole in a soft-wooded tree, usually in a dead branch or main stem, excavated by the bird itself, for which purpose its heavy bill seems well adapted.

The nest-hole is rather small, about five inches in diameter, and the passage leading into it is about six inches to two feet long, about two and a half inches in diameter, and very smoothly rounded off inside and bevelled off at the entrance, which is often situated on the underside of a branch and which in any case is always so placed that it does not face upwards, thus avoiding flooding of the nest-hole by rain. The nest is usually placed fairly high up in a tree, twenty feet or more above the ground, but may occasionally be found lower down. No regular nest is constructed, the eggs being placed on a few chips of wood in the nest-hole.

In Bihar the nesting season is chiefly in March and April, but further North eggs may be found in May or even in June. The eggs, which are dull white, and slightly glossy, measure about 30 by 22 mm., and three or four eggs are usually laid.

The Green Barbet is now divided into three subspecies, the typical form (*T. zeylanicus zeylanicus*) being found in Ceylon and South Travancore, the form found along the West coast of India from North Travancore to Bombay being *T. z. inornatus*, and that found in Northern India, from the extreme West to Western Bengal, being *T. z. caniceps*. It is this last subspecies which is represented in our Plate.

THE UTILIZATION OF INDIGENOUS PHOSPHATES IN INDIA.

BY

C. M. HUTCHINSON, C.L.E., B.A.,

Imperial Agricultural Bacteriologist.

NEXT in importance to nitrogen, as a soil constituent requiring renewal, comes phosphorus, the supply of which in farmed lands has been a source of anxiety to the cultivator ever since it was discovered to be a necessity for the growing crop. Nitrogen can be transferred to the soil from the inexhaustible supply in the air by green manuring and the use of leguminous crops, but no such natural means of renewing the soil supply of phosphorus exists and for this reason the question of its presence in adequate quantity is an acute one for the farmer. Although phosphatic manures were used in very early times it was not until de Saussure discovered their fertilizing action to depend upon their content of phosphorus that any attention was paid to the question of the actual utilization of this constituent, and particularly to the reasons underlying the comparatively slow action of such phosphatic manures as were then available.

Bones were used very early as fertilizers but the slowness of their action was always recognized. The first step taken to reduce this disability was the use of grinding machinery by Anderson of Dundee in 1829; there is also evidence of the early use of fermentation with organic matter in the form of composts. That the fertilizing action of such manures was due to phosphorus was not known until the time of de Saussure, and was emphasized by Liebig when stating his law of the minimum. It was Liebig in 1840 who suggested the use of sulphuric acid as a means of hastening the fertilizing action of bones and this was taken up by Lawes and extended to include mineral phosphates, especially coprolites. This was the

origin of the superphosphate industry which now supplies available phosphates to crops all over the world.

Consideration of the economic aspects of the use of sulphuric acid for solubilizing phosphates led to recognition of the fact that as superphosphate only contains about half the quantity of phosphoric acid which is present in the rock phosphate from which it is made, this available phosphate is not only more costly than the original inert form, but transportation charges are correspondingly greater. Consequently much experimental work has been carried out to discover the possibility of making successful use of the original rock phosphate brought as nearly as possible into an available condition by fine grinding. It is now fairly well known under what conditions such finely ground but chemically untreated phosphates may be used with success, and it may be of interest to state here the conclusions arrived at in general terms.

- (1) The value of ground phosphate is strictly determined by the fineness of the grinding.
- (2) No good results can be expected in soils deficient in organic matter, but in those containing a high percentage of humus, finely ground rock phosphate may give as good results as equivalent amounts of superphosphate.
- (3) In highly calcareous soils unless the supply of organic matter is maintained at a high level, no good results can be expected with rock phosphate. It may be mentioned here that, so far as the highly calcareous soils of North Bihar are concerned, this restriction also applies to superphosphate as has been shown by many experiments at Pusa.

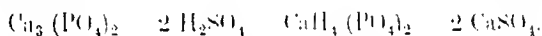
A recent method of attacking this problem consists in carrying the mechanical subdivision of the mineral phosphate to a much further degree of fineness by special grinding machinery, resulting in reduction of the particles to the colloidal state. The relative economic efficiencies of this method and of the chemical one will evidently depend very largely upon the cost of the mechanical disintegration, but it is probable that this latter method may have a

special value for low grade phosphatic minerals whose content of iron or other impurities renders them unsuitable for the production of superphosphate.

Many experiments have been made with a view to increasing the availability of rock phosphates by what may perhaps be styled natural means, such as by contact with fermenting organic matter. In such empirical experiments many substances have been made use of, including peat and farmyard manure: laboratory work introducing examination of the action of bacteria in such mixtures has been carried out by numerous investigators: although positive results showing solvent action were sometimes recorded the general conclusions arrived at were unfavourable to the supposition that the fertilizing action or, at any rate, the solubility of rock phosphates could be increased to any serious extent by this method. On the other hand it is possible to show, as has been done in the writer's laboratory at Pusa, increased fertilizing effects on growing crops, apparently due to partial solubilization of mineral phosphates by the fermentative action of bacteria, in composts with such organic materials as oilcake and green manures.

A great step in advance was made when the oxidation of sulphur and formation of sulphuric acid by certain classes of soil bacteria was shown by Lipman in 1915 to be of practical importance as applied to the problem of solubilization of mineral phosphates. It is interesting to note that the same idea was made the subject of a patent by Panknin in 1877 and later by Chisholm in 1904, but the failure of either of these to secure practical recognition was evidently due to their ignorance of the biological factor involved and consequently of the essential conditions necessary for success. Lipman, McLean, Waksman, and others have placed this matter on a sound practical basis, and work at Pusa during the past three years has demonstrated the possibility of making use of the method in India. It has been shown at Pusa that the addition of sulphur to a compost containing indigenous mineral phosphates results in partial solubilization of the latter as a result of the oxidation of the sulphur by soil bacteria, and that such composts exercise a fertilizing action on growing crops. It has been further

shown that such solubilization of phosphates is greatly increased by the use of cultures of sulphur oxidizing bacteria, isolated in the first place from such composts, as much as 88 per cent. of the insoluble mineral phosphate being rendered available in ten weeks. The results of a typical experiment are given in Tables I and II. Further experiments are in progress to determine the optimum conditions required for this process, and the relative quantities of sulphur and rock phosphate involved. With regard to this last point it must be remembered that there is a definite quantitative ratio between the amount of rock phosphate to be solubilized and that of the sulphur required for this purpose, the actions involved being purely chemical although resulting from biological metabolism; the particular reaction resulting in solubilization of tricalcic phosphate commences with the formation of sulphuric acid and the amount of this, and consequently of its constituent sulphur, required for completion of the desired change may be calculated from the formula :-



Then 310 parts by weight of tricalcic phosphate require 64 parts of sulphur for complete reaction, giving a ratio of one part of sulphur to five parts of rock phosphate. In actual practice various considerations modify this ratio, the principal one being the limitation of the oxidation of the sulphur to some 70-75 per cent. of the amount present in the period of time, some ten to fifteen weeks, conveniently occupied by the process. The diversion of some proportion of the oxidized sulphur into combination with other substances present, either as impurities in the rock phosphate or in the soil used for dilution of the compost, must also be taken into account. On the other hand the nature of the rock phosphate and its probable content of other minerals than tricalcic phosphate themselves unacted upon by the oxidized sulphur, will reduce the amount of sulphur required. McLean in America has found a ratio of 120 parts of sulphur to 400 parts phosphate satisfactory in presence of 2,000 parts of soil, and this sulphur-phosphate ratio has also been found satisfactory at Pusa. With reference to the proportion of soil and the necessity of using this latter as an ingredient of such composts, there is at

present considerable difference of opinion and experience; it is obvious that the handling of large quantities of soil will necessarily increase the cost of this method, but there are hopeful indications that the proportion of this ingredient may be considerably reduced and in fact that it may possibly be eliminated altogether.

This question is under experiment at Pusa at present, but it is clear that the character of the soil itself must play an important part in deciding it; in many instances this factor will carry very considerable weight, as for example in the case of most of the tea soils of Assam whose deficiency in lime will offer specially favourable conditions for the solubilization of the rock phosphate; this process will further be facilitated in these soils, where aeration, an essential condition for success, is readily secured and already arranged for in the routine of garden cultivation.

In whatever manner soluble phosphate is produced from mineral or other insoluble phosphates, on introduction of the resulting soluble product into the soil, reversion to the insoluble form will take place at a rate varying with the amounts of various substances, such as lime, present in the soil itself. As the plant can only take up its requisite supply of phosphatic and other nutriment at a pace which is limited by its rate of growth and assimilative capacity, the ultimate fate of the soluble phosphate applied as manure to the soil will depend upon two opposing factors, the rate of assimilation by the plant and the rate of reversion in the soil. To these two may be added a third, namely, the absorption of phosphate by micro-organisms in the soil, which, although it is probably of considerable importance, may be left out of consideration for the present as not affecting the question at issue to the same extent as chemical reversion. Now the use of a properly constituted compost containing mineral phosphates with the due proportion of sulphur, and inoculated with the appropriate sulphur oxidizing bacteria, would tend to overcome this difficulty by providing a continuous, although small, supply of soluble phosphate, as the oxidizing action would continue in the soil receiving the mixture provided adequate aeration and moisture were secured. Although it would, of course, be impracticable to make any accurate measurements which would

allow of exact adjustment of the two rates of solubilization and assimilation, nevertheless it is obvious that such a method of making use of the natural sulphur oxidizing power of soil organisms would be preferable to that of merely obtaining soluble phosphates by this means, and applying the product, as superphosphate is applied, in one dose with the inevitable result of loss by reversion. Here we have a parallel to the case of nitrogen supplied as nitrate of soda, much of which is lost to the crop in Indian soils partly as a result of leaching by rain and partly by reduction and assimilation by bacteria. The manurial value of oilcake as a source of nitrogen is well known to be high in this country and the writer demonstrated many years ago the notable advantages of the divided dose in applying cake in the cultivation of tea, this advantage being undoubtedly due to the continuous supply of nitrate secured to the growing crop by the nitrification of the cake, and the extension of the period of this supply and the avoidance of loss by use of the method of the divided dose.

In place, therefore, of making use of a fully matured compost, i.e., one in which oxidation of the sulphur and with it solubilization of a corresponding proportion of the mineral phosphate had been carried to a conclusion, such a compost might with advantage be applied to the soil requiring phosphate manuring at an earlier stage of maturity, so as to secure the continued and gradual supply of soluble and available phosphate the advantages of which have been indicated above. Selection of the particular stage of maturity most suitable for use with varying crops and soils would be a matter for experience and experiment to determine, but there can be no doubt that this method would in many cases present advantages over direct application of fully matured composts, just as the bringing into use of indigenous supplies of phosphates in this country by making use of natural fermentative processes must constitute an advantage over the importation of superphosphate from abroad or even over that of manufacture by chemical processes in India.

As will be seen from the results given in Tables I and II the use of cultures of sulphur oxidizing bacteria is necessary to obtain any high degree of solubilization. On the other hand it is not essential

to use pure cultures, nor has this been done by most workers on this subject, partly because of the difficulty of obtaining them in an active condition, but largely because of the effectiveness of inocula merely drawn from composts in which sulphur oxidation has been firmly established by suitable treatment. This method is very similar to that made use of in connection with nitrification both of sewage and in saltpetre production, and there are further resemblances between these two natural oxidation processes which will be referred to again later in this paper. As a practical method, therefore, there is nothing to prevent its adoption by properly instructed, although otherwise entirely unscientifically trained individuals, and although in the initial stages of its adoption and use it might be advisable to make use of a certain measure of scientific control, involving perhaps the preparation of the composts at centres of distribution, later on there should be nothing to prevent the cultivator from preparing his own composts, making use of inocula originally provided, preferably by officers of the Agricultural Department, but subsequently carried over from one preparation to the next in a manner familiar to the makers of both country spirit or rice beer, and of curdled milk (*dahi*).

It is interesting to note that the addition of sulphur to soils produces fertilizing effects which may be attributed to actions other than that of solubilization of phosphate. So far, although many guesses have been made to account for this result, we have no accurate knowledge sufficient to account for it. The increased fertility has been attributed to partial sterilization, to the production of an acid reaction and consequent neutralization of excessive alkalinity, and to interference with the growth of injurious fungi, parasites and weeds. These latter claims have been made for a recent French patent which, however, makes no reference, at least in the published account of it, to the solubilization of phosphates, and appears to be no great advance upon the earlier patents of 1877 and 1904 except in regard to the recognition of the biological factor. Experiments in the writer's laboratory in 1912 showed very varying effects of the addition of sulphur upon the bacterial content and activities in different soils. A selective action was evident,

resulting in multiplication of certain species with diminution of others, but this was evidently attributable to the modified reaction of the soil due to formation of acid, nor was it possible with the data obtained to draw any valid conclusions as to the causes of increased fertility from the observed effect of added sulphur upon the bacterial processes usually associated with this condition. The striking results of the addition of sulphur to the soil of Assam tea gardens in the relatively small quantities provided by the operation of sulphuring the bushes against "red spider" attacks, was pointed out to the writer in 1934, and it was further evident that the increased growth of leaf in many cases resulting from this operation could hardly be due to the reduced activity of the insect attack, as it appeared in situations practically free from the latter. In view of the importance of the action of sulphur bacteria as potential providers of available phosphate from otherwise insoluble minerals, and the possible introduction of the use of the "immature" composts described above with their content of unoxidized sulphur, it would probably be worth while carrying investigation of the other actions of sulphur in the soil to a further degree than has hitherto been done, and such an enquiry may be recommended for consideration by soil chemists, mycologists, entomologists, and bacteriologists as worthy of attention.

An interesting parallel exists between the activities of sulphur oxidizing and nitrifying bacteria in soils. Both are oxidation processes requiring adequate aeration and a sufficiency of moisture and both result in the neutralization of the acid formed by combination with a base. In the case of the sulphur bacteria these organisms are able to function in the presence of a high concentration of the acid by-product of their metabolism, whereas the activity of the nitrate formers is strictly limited by any such accumulation and requires the presence of a base, such as lime, to avoid interference with the process. On the other hand both classes of organisms are sensitive to the inhibitory action of excess of organic matter, the presence and character of which requires careful regulation if satisfactory results are to be obtained. Long experience has taught the practical agriculturist, as well as the sewage expert,

in what manner the problem of the nitrification of large quantities of organic matter may be dealt with, and it is probable that, where the combination of the latter with minerals in a compost is likely to be of value, careful experimental work will discover practicable methods of carrying this out without prejudice to the oxidation of sulphur and the resulting solubilization of the tricalcic phosphates present. The above described parallelism between sulphur oxidation and nitrification suggests a highly desirable alternative to the former process as a means of obtaining soluble phosphates from natural mineral sources. In theory there is no reason why the second process should not be substituted for the first as a means for attaining this end, the tricalcic phosphate serving as the base to neutralize the nitrous acid resulting from the nitrification of the organic matter present. Hopkins has shown that soluble phosphate can be got as a result of the normal processes of nitrification in presence of rock phosphate, and although at present the practical application of this method has still to be worked out, the obvious advantage of being able to dispense with the necessity of spending money on sulphur, indicates the advisability of research into the possibilities of this alternative method in a country where climatic conditions are generally favourable to a high rate of nitrification. Considerations of space preclude further discussion of this subject, but it may be said here that work in the writer's laboratory has demonstrated the possibility of greatly increasing the activity of nitrifying organisms and the rate of nitrification, by simple bacteriological methods, which may possibly be applied successfully to the practical elucidation of this interesting problem.

In conclusion it may be pointed out that India possesses deposits of natural rock phosphates, such as those of Trichinopoly and Bihar, and also an unfailing supply of bones, neither of these potential sources of phosphatic plant food being at present utilized to any considerable extent for manurial purposes. One reason for this neglect of such sources of soil fertility is the simple economic one of the cost of the manure and the relations between this amount and the value of the increased crop obtained by such expenditure; this in many cases, if not in most, does not present a balance on the

right side when the cost of imported superphosphate is concerned, nor in the present stage of industrial development of this country is it probable that locally produced superphosphate would improve the position. The cost of production of superphosphate in this country would be largely influenced by the capital cost of the plant for production of acid and treatment of the mineral phosphate therewith, together with the heavy overhead and depreciation charges associated with such enterprises in India. These, rather than the cost of raw materials, would probably determine the economic balance of such an undertaking, whereas, by making use of natural fermentative processes such as that outlined above, these heavy additional expenses are largely eliminated. It is not claimed that by so doing available phosphates can be obtained at a negligible cost; there will still remain the necessity of providing grinding machinery and of paying for the sulphur and the raw phosphatic materials and their handling and transport. It remains to discover whether the elimination of the manufacturing costs of sulphuric acid and of superphosphate in India will reduce the final cost of available phosphate, made by this natural process from indigenous materials, to such a degree as to allow of the extension of its use beyond the narrow limits which at present confine its application to a small minority of revenue crops. The object of this paper is to suggest such a possibility and also to draw attention to the advisability of investigation of the subject by competent and interested workers in this country.

TABLE I.

Solubilization of mineral phosphate by sulphur oxidizing bacteria.

Period	Mg. of P_2O_5 as rock phosphate	Mg. of P_2O_5 found available	Mg. of P_2O_5 solubilized	Per cent. of insoluble P_2O_5 solubilized
CULTURE No. 1 .. At start ..	281.6	25.6 *	..	...
After 2 weeks ..		30.8	5.2	2.03
After 4 weeks ..		53.2	27.6	10.78
After 8 weeks ..		152.8	127.2	49.70
After 10 weeks ..		196.9	171.3	66.90
CULTURE No. 2 .. At start ..	281.6	25.6	..	...
After 2 weeks ..		34.2	8.6	3.39
After 4 weeks ..		47.9	22.3	8.71
After 8 weeks ..		178.9	153.3	59.80
After 10 weeks ..		233.4	227.8	88.96

* Contained in culture medium.

TABLE II.

Action of sulphur oxidizing bacteria on mineral phosphate and on pure tricalcic phosphate, in 10 weeks' time.

	Mg. of P_2O_5 added	Mg. of P_2O_5 found available after 10 weeks	Increase over control	Per cent. of insoluble P_2O_5 rendered soluble
(1) Action on mineral phosphate				
Control ..	281.6	25.6 *	..	...
Culture No. I ..	..	196.9	171.3	66.9
Culture No. II ..	..	233.4	227.8	88.9
(2) Action on pure tricalcic phosphate				
Control ..	302.0	56.2	..	...
Culture No. I ..	..	216.0	159.8	65.0
Culture No. II ..	..	292.0	235.8	95.9

* Contained in culture medium.

SOME CORRELATIONS IN THE CHARACTERS OF KANKREJ CATTLE IN THE BOMBAY PRESIDENCY.

BY

E. J. BRUEN.

Deputy Director of Agriculture for Animal Breeding, Bombay Presidency.

IN the Bombay Presidency, there are large numbers of professional cattle breeders who have been engaged in this work for many generations. Like the old breeders of European countries these are usually illiterate but at the same time very observant of points in their cattle. The vast amount of knowledge thus accumulated for generations has been handed down not in the form of characters which are connected with good qualities, but as superstitions regarding lucky and unlucky markings. For instance, a cow or bull with a "feather" situated in a particular spot is supposed to make it an extremely lucky or unlucky animal to the owner.

As the cattle breeders have such superstitious fancies it is difficult to distribute bulls bred on Government farms, no matter how well-developed they may be, if they do not possess these "lucky" signs or markings. Due to this, numbers of well grown bulls of known and good pedigree are continually being left on these farms to be eventually castrated. It is evident, in fact, that if the cattle of the country are to be improved, it will be necessary for a long time to come that due consideration be given to the opinions and prejudices of the breeders with whom we must work.

The Manager of the Northcote Cattle Farm, Chharodi, Mr. M. M. Desai, has endeavoured to correlate some of these lucky signs with the more regular methods of judging or selecting cattle. Until our breeders become more familiar with the pedigree

system of selecting cows, I believe it is our duty to set out the advantages and disadvantages of a particular type of animal to them in such a manner that they will, to their own way of thinking and judging, accept what we realize to be really good material. It is my conviction that all these lucky or unlucky signs require investigation, and that, if this is made, many of them may be found to be closely correlated with really useful characters in the stock. I therefore give below a few of the signs of the Kankrej cattle of Gujarat which are held in high repute by the "Rabari" or professional Kankrej breeder, and their correlation with our own observations.

It is undoubtedly due to strict adherence to the principle of utilizing as far as possible only cattle possessing such markings that the Kankrej, or for the matter of that any pure breed in India, has been kept up to the standard in which we find it to-day. I may here observe that we find good and pure cattle only in those areas where there is such a person as a professional breeder.

(1) *Length of face.* The professional breeder of Kankrej cattle gives preference to a short face, this being the first part of the external anatomy to be examined in selecting an animal. No matter what other good qualities it may possess, if the face is not short the animal is rejected. No Rabari will accept a bull with a long face to head his herd. The professional breeder, however, cannot offer any explanation as to why he prefers an animal with a short head.

The connection of the length of face of a Kankrej cow with the age at which it matures has been tested in a large number of cows of the Chharodi herd. The time of maturing has been measured by the age at which the first calf was dropped, and the attached correlation table between the two characters shows their relationship. The age at which the first calf was dropped has been classified to within six months, none being dropped under the age of $3\frac{1}{2}$ years.

A study of the figures shows that there is a correlation, though only a slight one, between the characters studied, and thus there is a distinct likelihood for a long faced animal to be late in maturing. Taking unity (1) as representing absolute connection between the

Correlation between length of face and age of dropping first calf.

Length of face in inches	AGE OF DROPPING FIRST CALF										TOTAL
	3½ to 4 years	4 to 4½ years	4½ to 5 years	5 to 5½ years	5½ to 6 years	6 to 6½ years	6½ to 7 years	7 to 7½ years	7½ to 8 years	8 to 8½ years	
18	1	3	..	1	1	..	..	..	6
18½	..	1	1	2	1	1	..	..	..	..	10
19	..	1	2	4	8	7	6	2	1	1	31
19½	..	1	1	1	5	3	1	1	1	..	14
20	1	5	12	2	1	3	2	1	27
20½	1	3	1	2	..	..	..	7
21	1	..	2	2	..	..	..	..	5
22	1	..	..	1	..	2
TOTAL	3	6	11	27	20	15	9	5	2	3	105

two characters, the coefficient of correlation works out as -0.183 with a probable error of ± 0.064 . This high probable error suggests that the number of observations has not been sufficient to make the correlation a certain one, and it is obvious that the matter needs further study with a larger range of animals. I am putting the figures on record, however, because if such a correlation be established in any breed of Indian cattle the length of face would become a very important indication in breeding in this country.

(2) *Length of ear.* Long pendulous ears are much preferred in Kankrej animals by the breeders of Upper Gujarat and this would appear, by the measurements made on the Chharodi herd, to have a correlation with the length of the body. The tendency would appear to be for a long ear to be associated with a long barrel, and the longer the barrel the better the constitution, the more food space and better digesting power. The following correlation table between these two characters shows their relationship in 95 animals of the Chharodi herd.

Correlation between length of ear and length of body.

Length of ear in inches	LENGTH OF BODY IN INCHES									TOTAL
	26-26½	27-27½	28-28½	29-29½	30-30½	31-31½	32-32½	33-33½		
10-10½	1	4	2	1	..	..	..	..		8
11-11½	..	1	5	3	1	1	..	..		11
12-12½	..	7	9	6	1	2	..	..		25
13-13½	1	3	5	7	2	3	..	2		23
14-14½	..	1	7	3	9	2	1	1		24
15-15½	..	..	..	2	..	1	..	..		7
16-16½	..	..	..	..	1	..	..	..		4
TOTAL	2	16	28	22	14	9	1	3	9	

The mean length of the ear in the animals examined was 12·8 inches, and the mean length of the body was 30·4 inches. The correlation in this case, while still not very strong, is obviously closer and more certain than in the previous case described. Here again, taking unity (1) as representing absolute connection between the two characters, the coefficient of correlation works out as + 0·327 with a probable error of $\pm 0·062$. Though the association of long ears and long body is not by any means constant, yet there is certainly sufficient correlation to justify the use of length of ear as one of the factors in the choice of undeveloped animals.

(3) *Dewlap*. The larger and more pendulous the dewlap the better the Rabari likes the animal. This particular development is known as *od*. The cows on the Northcote Cattle Farm, Chharodi, have not been milked in the past. Milking has only been taken in hand within the last three years, and naturally a number of cows on the farm give little or no milk. The dewlaps of some 130 cows have been measured, and, as will be seen by the figures given, there seems to be a greater percentage of animals with large dewlaps in the milking herd than of those with a smaller dewlap.

The natural inference is that length of dewlap is correlated with the milk-yielding capacity—the longer the dewlap the greater the milk.

Correlation between length of dewlap and milk-yielding capacity.

Dewlap in inches	Total number of animals considered	Number of animals found yielding	Number of animals found not yielding	Percentage of yielding animals
5½ - 6½	20	6	14	30.0
7 - 7½	32	9	23	28.1
8 - 8½	32	9	23	28.1
9 - 9½	20	9	11	45.0
10 - 10½	17	7	10	58.8
11 - 11½	9	6	3	66.6

The figures are by no means conclusive, but they certainly suggest a certain association of the milking capacity with a long dewlap. It is not possible in this case to give a precise measure of this correlation, but it certainly suggests further observations along these lines.

IRRIGATED PADDY: A CONTRIBUTION TO THE STUDY OF FIELD PLOT TECHNIQUE.

BY

LESLIE LORD, B.A. (Oxon.).
Deputy Director of Agriculture, Burma

INTRODUCTION.

THIS paper is the result of experiments initiated at Mandalay in 1921 with the object of determining the error of field trials with irrigated paddy and of finding a means to reduce that error. The probable error of small bundled plots at Mandalay had been found to work out to the high figure of 13 per cent., so it was suggested to the writer* that the error of long narrow plots *within* a bundled field should be determined. Errors were calculated by the ordinary and by "Student's" method.¹ "Student's" method largely reduces the error and a modification of this method still more so. As the results obtained may be of interest to other workers this short paper, which is only intended as a small contribution to the study of field technique, has been prepared.

PREVIOUS WORK.

An excellent summary of the work already carried out on the subject of error in field trials is given by Batchelor and Reed² (1918). It is curious that no mention is made of "Student's" method which is given as an appendix to Mercer and Hall's paper³ (1911). Parnell⁴ (1919) dealt with the problem in Madras and by

* By Mr. A. McKerral, Officiating Director of Agriculture, Burma, who also suggested the method used in these experiments to demarcate plots.

¹ Mercer, W. B., and Hall, A. D. "The experimental error of field trials, with Appendix by "Student." *Jour. Agri. Sci.*, IV, 2, pp. 167-182, 1911.

² Batchelor, L. D., and Reed, H. S. "Relation of the variability of yields of fruit trees to the accuracy of field trials." *Jour. Agri. Res.*, XII, 5, pp. 215-283, 1918.

³ Mercer, W. B., and Hall, A. D. *Ibid.*

⁴ Parnell, F. R. "Experimental error in variety tests with rice." *Agri. Jour. Ind.*, XIV, 5, pp. 747-757, 1919.

using plots 50 feet \times 4 feet was enabled to reduce the probable error of the difference of *adjacent* plots to 4.2 per cent.; with plots 50 plants long and 2 plants wide the error of the difference of adjacent plots was found to be the low figure of 3.1 (per cent.). This paper also gives the errors of ordinary field plots in India for various crops calculated by the method of Wood and Stratton¹ as corrected by Parnell. Stadler² (1921) drew attention to the effects of competition in cereals grown on small test plots and showed a method of preventing this. Where new selections or varieties are under trial at an early stage when seed is scarce the question becomes very important. Beaven³ (1922) was the first to emphasize the value of "Student's" method in reducing the probable error of experiments, and his paper is of extreme interest and importance in all cases where small differences are being examined. He states that "the well marked reduction of the probable error by 'Student's' method is largely due to the fact that in this particular field the fertility declines, although not uniformly, from east to west. At another station where divergencies were more irregular in character there might be less difference in the probable errors obtained by the two methods. It appears to the writer, however, to be clear that the second method gives the probable error more correctly and it is more difficult to calculate." Faulkner⁴ (1923) has made a quantitative comparison of the accuracy of "Student's" method with the ordinary.

THE VALUE OF THE STATISTICAL STUDY OF EXPERIMENTAL RESULTS.

The necessity of a statistical interpretation of the results of field trials is now widely acknowledged but its importance has in many cases been overlooked, e.g., "for the most part the tests of outcross of the different varieties of crops were made on a number

¹ Wood, T. B., and Stratton, T. J. M. The interpretation of experimental results. *Trans. Roy. Soc. Edin.*, III, 4, pp. 417-449, 1909.

² Stadler, L. J. Experiments in crop production made on small test plots. *Trans. Roy. Soc. Edin.*, 49, 1921.

³ Beaven, E. S. Trials of new varieties. *Trans. Roy. Soc. Edin.*, 47, 1, July and August 1922, and Supplement.

⁴ Faulkner, O. F. The probable error of field experiments. *J. Roy. Stat. Soc.*, XVIII, 3, pp. 238-248, 1923.

of duplicate fields quite inadequate to prove (within stated limits of probability) that the differences observed were systematic and not due to genetic or environmental variation.”¹

Attempts are sometimes made to reduce the error of trials by averaging results over a period of years; of this, Fisher² (1921) at Rothamsted found that “average wheat yields, even over long periods from different fields or for different seasons, cannot approach in accuracy the comparison of plots of the same field in the same season.” It has been noticed that in some cases the yield of a treated plot in one year has been compared with the mean of the control plot over a number of years which means that the effect of the seasonal variation which is exerted with full force on the treated plot is only partially exerted on the control.

STATEMENT OF THE PROBLEM.

Comparatively small differences in yield between two varieties or owing to different treatments are often of sufficient value to cause the new variety to be used or the new treatment to be adopted. But where only small differences are obtained it becomes very difficult to state mathematically that these differences are significant and therefore if the new variety or treatment is really superior. The problem is to reduce the probable error to such an extent that even small differences can be shown to be significant.

METHODS.

Long narrow plots within a banded field were chosen as offering the best chance of successfully tackling the problem. In 1921-22 the plots were 6·6 feet wide by 122 feet long (area 0·0184 acre), and in 1922-23, owing to a re-arrangement of the experiment, the plots were 6·6 feet wide and 174 feet long (area 0·026 acre). In the first year the number of plots was 104 and in the second 72. Plots adjoining bands were discarded. Four banded fields were used in both years. The plots were demarcated by a variety of paddy (*Mo Hnaw*) which, in all stages of its growth, possesses

¹ Jacob, S. M. *Rept. Punjab Dept. of Agri.*, 1921-22, Pt. I, p. 3.

² Fisher, R. A. *Studies in crop variation, I. An examination of the yield of dressed grain from Broadbalk.* *Jour. Agri. Sci.*, XI, pp. 107-135, 1921.



FIELD PLOTS.

characteristics easily distinguishing it from the pure line Ngasein paddy used in the experiment. The two photographs (Plate I) give a slight idea of this.

The fact that plots are demarcated by lines of paddy only, appears, in the case of paddy, to preclude the adoption of this method for manurial experiments. As well as long narrow plots, single lines of paddy were planted in the hope of discovering a reliable method of testing selections and varieties in cases where only small amounts of seed are available. In plant breeding work, e.g., such a method would enable a breeder to find out and discard useless types at least a year sooner and there would be a large saving in the area of land required. In this experiment only one strain of paddy was grown, so no question of competition arises. This matter requires further investigation but the method used here (lines 3.3 feet apart and plants 18 inches apart in the lines) would seem to preclude the possibility of serious competition. In 1921-22 lines were 122 feet long parallel to the water course. There were 103 lines and the lines adjacent to bunds were discarded. In 1922-23 lines were planted at right angles to the water course and were 174 feet long. Eighty lines were laid down. Owing to the prevalence of crabs at Mandalay this part of the experiment was not successful and it has not been thought worth while to include the results in this paper. In some of the single lines as many as 10 per cent. of the plants were cut down by crabs in a single night and a nursery had to be maintained in order to replace these plants. Further investigation in the light of this experience and in view of the effect of competition described by Stadler (*loc. cit.*) is necessary.

For the ordinary method of computation the following formula was used:—

$$\sigma = \sqrt{\sum \bar{d}^2 \over n} \quad \text{and}$$

$$\text{Probable error} = \pm 0.6745 \sigma$$

$$\text{Probable error of difference on 2 plots} = \pm 0.6745 \sigma \times \sqrt{2}$$

In "Student's" method the differences of adjoining plots were

calculated and the standard variation of these differences worked out. This figure multiplied by ± 0.6745 = probable error of difference of 2 plots. For purposes of comparison this figure has been worked out as a percentage of the mean yield of all the plots in the particular series.

The third method used in computing errors and the method which has given the best results may be termed "Student's" method modified. Instead of getting differences of adjacent plots, one plot was compared with the mean of the two plots on either side, e.g., if the plots are 1, 2, 3, 4, 5, 6 2 is compared with $\frac{1+3}{2}$; 4 is compared with $\frac{3+5}{2}$ and so on. The differences so obtained are used in the ordinary "Student's" method.

RESULTS.

The yields of the 1921-22 plots are shown in Plate II. Two facts are illustrated by the graphs:—

- (1) The yields are highest near the water course and there is a more or less regular decrease across the field.
- (2) There is a local increase near the bunds on the far sides of the fields. Yields of plots adjacent to bunds were not used in the calculation of probable errors.

The influence of contiguity to the water channel on yields of plots is probably due to the large amount of silt carried in the irrigation water. Most of this silt is deposited near the water course. The errors are given below:—

1921-22 plots.

	Ordinary method	"Student's" method
	Per cent.	Per cent.
Probable error of single plot	± 8.24	....
Probable error of difference of two plots ..	± 11.61	± 5.95

In 1922-23 the plots were laid down at right angles to the water course in order to discount its effect on yields. The results of these plots are shown in Plate III and it will be seen that there

PLATE II.

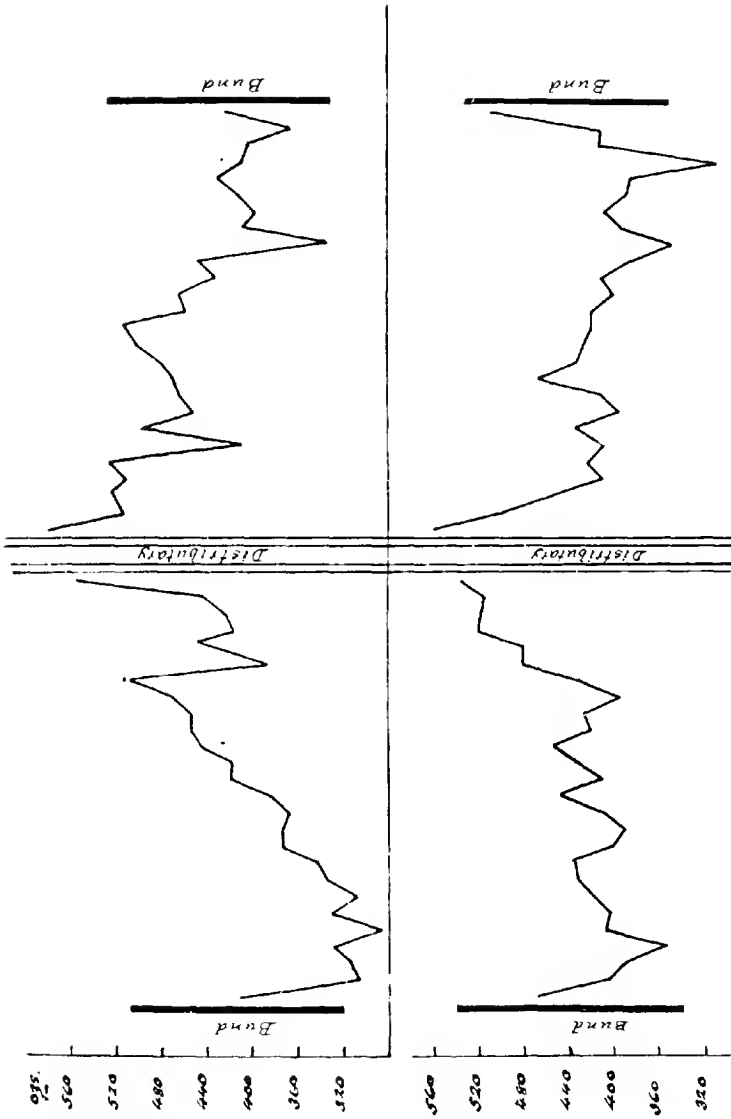
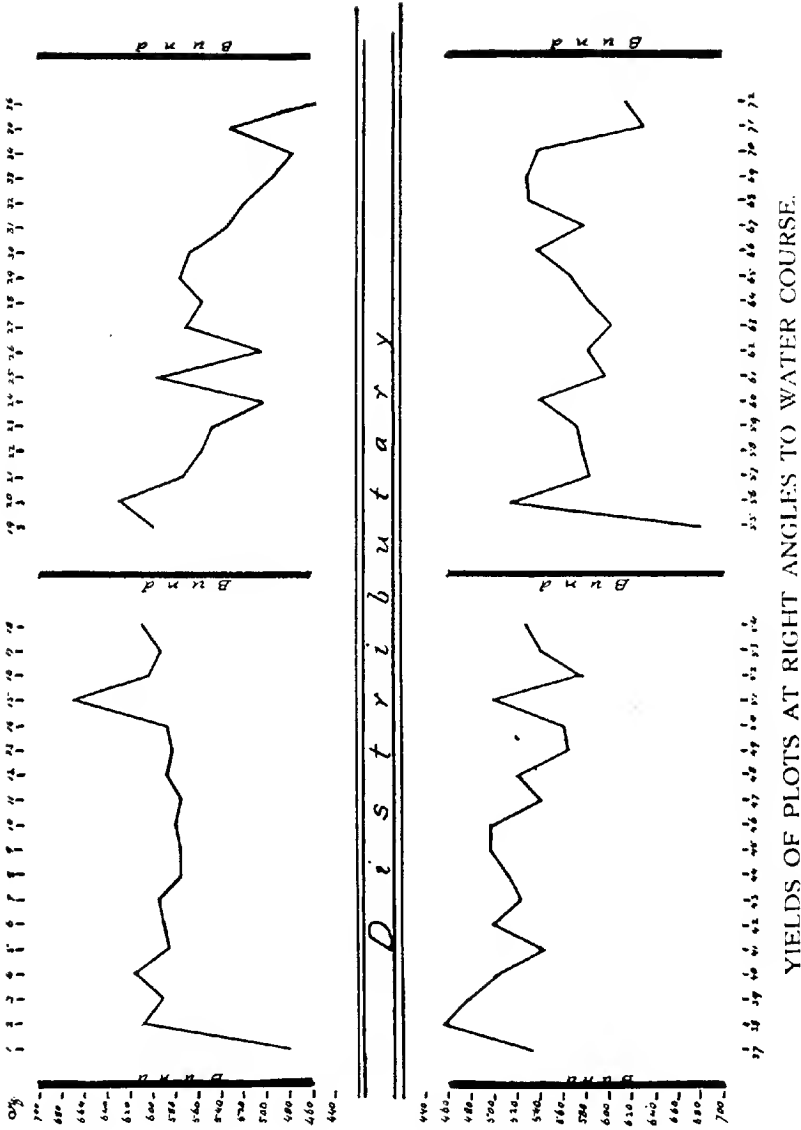


PLATE III.



is no fertility slope in the fields. Plots were planted adjacent to the bunds but were not weighed and included.

1922-23 plots.*

	Ordinary method	"Student's" method	"Student's" method modified
	Per cent.	Per cent.	Per cent.
Probable error of single plot ..	± 5.58	....	....
Probable error of difference of two plots ..	± 7.86	± 5.62	± 4.47

The re-arrangement of the plots in this year has made a noticeable difference but in both years the probable error calculated by "Student's" and the modified method is considerably smaller. As is to be expected, the decrease in the error found by "Student's" method is much larger when there is a fertility slope in the field.

The 1922-23 figures were used to compare the errors of the individual fields with the whole series, with the following results:—

Field No.	Ordinary method; probable error of single plot	"Student's" method; probable error of difference of 2 plots	"Student's" method modified; probable error of difference of 2 plots
	Per cent.	Per cent.	Per cent.
1	± 3.86	± 5.97	± 3.62
2	± 5.45	± 4.25	± 4.75
3	± 4.01	± 5.39	± 4.25
4	± 4.62	± 5.45	± 3.49
Average ..	± 4.48	± 5.01	± 4.361
Whole series ..	± 5.58	± 5.62	± 4.47

(It should be noted that the ordinary method only gives the probable error of a single plot.)

The inclusion of four separate fields in the series has had little effect on the results in either method. Four times the probable error of the difference of two plots may be taken as being significant, so even with "Student's" method a certain number of replications are necessary to reduce the error of the difference to a workable

* The writer is indebted to Mr. W. M. Clark, Deputy Director of Agriculture, Burma, for assistance in calculating the 1922-23 result

figure. Theoretically the probable error of the mean of a number of replications is $\frac{P. E.}{\sqrt{n}}$ where n equals the number of replications but in practice it is found that systematic replication does not reduce the error according to the theoretical calculation.

Mercer and Hall (*loc. cit.*) recommend the use of five replications; Roemer¹ states that when the experiment is repeated on more than six plots it does not contribute to any important extent to the accuracy of the "einzelbeobachtung"; at the Minnesota Experimental Station it was shown that variability decreased rapidly up to three replications, but only slowly thereafter. With "Student's" method the following results were obtained with the 1922-23 yields. Probable error of the difference of 2 plots = ± 5.62 per cent.

Replications				Theoretical	Calculated
				Per cent.	Per cent.
2	± 3.98	± 3.14
3	± 3.25	± 3.83
4	± 2.81	± 2.61
5	± 2.51	± 2.53
6	± 2.29	± 2.08
7	± 2.12	± 2.19

The theoretical and calculated errors of replications were also worked out by "Student's" method modified, with the following results. Probable error of 2 plots = 4.47 per cent.

Replications				Theoretical	Calculated
				Per cent.	Per cent.
2	± 3.33	± 2.93
3	± 2.71	± 2.26
4	± 2.35	± 2.10
5	± 2.10	± 2.50
6	± 1.91	± 1.71
7	± 1.77	± 2.50

Six replications have given the best results in both methods and although absolute accuracy cannot be claimed for the calculated errors, yet there would appear to be good ground for claiming that with six replications the probable error of the difference of two

¹ Roemer, Th. Ueber die Technik der Feldversuche. in *Fukling's Landw. Zeitung*, Year 67, 5-8, p. 102.

plots can be reduced to 2 per cent. by "Student's" method and below that figure by that method modified.

In all of the above calculations grain weights of the plots have been used. In cases where it is desired by numerous replications to still further reduce the probable error a large amount of labour is involved in threshing individual plots. It had been found at Mandalay that the correlation coefficient between total weight and grain weight was 0.089 ± 0.02 . So the errors of the 1922-23 plots were calculated on total weights with the following results :—

Ordinary method	-Probable error of difference of 2	= ± 10.71	per cent.
"Student's" method	ditto	= ± 6.97	"
"Student's method modified	ditto	= ± 4.83	"

The increase in the probable error over that obtained when grain weights were used is only slight.

SUMMARY.

(1) Under irrigation the yields of plots parallel to the water course tend to increase as the water course is approached.

(2) The probable error of a series is only slightly affected by plots distributed in more than one banded field.

(3) The probable error of a series is materially reduced by using "Student's" method and by "Student's" method modified it is still more reduced.

(4) Six replications with "Student's" method modified will reduce the probable error of the difference of two plots to below ± 2 per cent. The best method, therefore, of conducting experiments with long narrow plots within a banded field is as follows :—

C.A.C.A.C.A.C.A.C.A.C. where C = the control and
A = the treated plot.

(5) The probable error obtained by using total weights is only slightly higher than when using grain weights.

* In working out the calculated errors, owing to the smaller number of averages available, the formula $\sigma = \frac{\sqrt{\sum d^2}}{n-1}$ was used.

LINSEED (*LINUM USITATISSIMUM*) HYBRIDS.

BY

R. J. D. GRAHAM, D.Sc.,

Formerly Economic Botanist to Government, Central Provinces ;

AND

S. C. ROY, L.Ac.,

Assistant Botanist, Central Provinces.

THIS crop was first studied in 1916 to elucidate the nature of a number of aberrant plants occurring in the linseeds grown from line cultures on the College Farm, Nagpur, the previous history stating that for 13 years the crop had been uniform. These rogues proved to be hybrids, the result of natural cross pollination. A large number of artificial crosses were raised during the succeeding four years. As the occurrence of natural cross pollination of linseed has not previously been noted in India, and as the figures collected indicate a simpler genotype for the Central Provinces' linseed than that described by Tammes¹ for flax, the facts are now recorded.

Linseed as grown for oil in India is a bushy plant, branching copiously from near the base, occasionally reaching a height of three feet. In the Central Provinces and Berars 5 per cent. of the total cropped area or nearly one million acres, chiefly in the Nagpur, Chhatisgarh and Berar Divisions, are annually sown with linseed either as a pure or mixed crop.

¹ Tammes. Die genotypische Zusammensetzung einiger Varietäten und ihr genetischer Zusammenhang; *Rec. d. trav. bot. néerl.*, XII, 1915. Die gegenseitige Wirkung genotypischer Faktoren; *Rec. d. bot. trav. néerl.*, XIII, 1916. On the mutual effect of genotypic factors; *Proc. Kon. Akad. v. Wet., Amsterdam*, XVIII, 1916. Genetic analysis, schemes of co-operation and multiple allelomorphs of *Linum usitatissimum*; *Jour. Gen.*, XII, 1922. Das genotypische Verhältnis zwischen dem wilden *Linum angustifolium* und dem kulturierten *Linum usitatissimum*; *Genetica*, V, 1923.

Anthesis and pollination in general conform to that described for flax in Holland by Tammes.¹ On a warm morning flowering starts at 7-30 a.m.—half-an-hour after sunrise—while on a cold dull morning it is delayed till 9 a.m., both the actual time of opening and the quantity of flowers being dependent on temperature and humidity. The flowers close by the afternoon and commence to drop only the day after opening, occasionally, however, still adhering even to the fruit.

The cylindrical stigmas which are adpressed together until the corolla has expanded, are receptive on the inner side. By the time the corolla is half expanded the extrose anthers, which in the bud are below but now are level with the stigmas, have dehisced. When the flower is fully open the anthers are forced close to the uncoiling stigmas by the elongation of the claws of the petals, the stigmas actually coming in contact with the pollen covered anthers as described by Loew,² and self pollination is effected. The protogynous condition described by Tammes³ does not occur naturally but is the result of wound and contact stimuli.

Prior to 1915, 14 cases of natural cross pollination occurred on the College Farm. In 1916, 1917 and 1919, only 9 cases were observed in 212 line cultures or less than 5 per cent, when linseed is grown in adjacent lines at Nagpur.

The characters studied in the crosses were first the colour of the corolla and next the colour of the seed-coat.

Blue-flowered × White-flowered.

F₁ had pale-blue flowers with dark blue veins like the blue parent. Twenty-seven plants were raised in F₂, 19 blue and 8 white-flowered; 12 of the blue-flowered again segregating into 937 blue and 319 white-flowered. The ratio obtained from 70 other segregating individuals was 3.205 blue : 1.069 white-flowered. These figures indicate a monohybrid cross.

¹ Tammes. Die Flachblüte. *Rec. d. trav. bot. néerl.*, XV, 1918.

² Loew, E. *Einführung in die Blütenbiologie*, 1895.

³ Tammes. *L. c.*, 1918, p. 220.

Dark brown seed × *Yellow seed*—*flowers white*.

F₁ had a dark brown seed-coat. In F₂ segregation occurred giving 15 dark brown and 5 yellow-seeded plants; 8 of the dark-seeded plants proved heterozygous, segregating into 634 dark brown and 187 yellow-seeded plants. The numbers obtained from 29 other plants were 1,463 dark brown and 460 yellow-seeded plants.

Dark brown seed × *Pale brown seed*—*flowers blue*.

F₁ had a dark brown seed indistinguishable from the dark parental type. The numbers obtained from 19 segregating plants were 409 with dark brown and 136 with pale brown seeds.

Blue flower, pale brown seed × *White flower, yellow seed*.

F₁ had normal blue flowers and pale brown seeds. The numbers obtained from 30 heterozygous individuals were 1,657 plants, blue flowers with pale brown seeds, and 547 plants, white flowers with yellow seeds.

The results of these three crosses indicate a single factor difference for seed-coat colour on the assumption that the yellow seed only occurs in the absence of flower colour.

Blue flower, pale brown seed × *White flower, dark brown seed*.

F₁ had the blue flowers of one parent and the dark seed of the other. Twenty-nine F₂ plants raised showed—17 blue flowers, dark brown seeds; 3 blue flowers, pale brown seeds; 8 white flowers, dark brown seeds; and one white flowers, yellow seeds. Ten individuals from the plants with blue flowers and dark brown seeds segregated into—445 blue flowers, dark brown seeds; 120 blue flowers, pale brown seeds; 124 white flowers, dark brown seeds; and 48 white flowers, yellow seeds. The progeny of 32 other artificial crosses segregated into—327 blue flowers, dark brown seeds; 130 blue flowers, pale brown seeds; 108 white flowers, dark brown seeds; and 35 white flowers, yellow seeds. This clearly indicates a dihybrid cross supporting the assumption that the yellow seed is a pale brown with pigmentation inhibited by the absence of flower colour.

In the linseeds studied in the Central Provinces there is thus present a factor for petal colour in whose absence the petals are white, and a factor for seed-coat colour in the absence of which the seeds are pale brown. If the factor for petal colour is absent, however, the seeds are yellow.

Analysis of the oil-content of the seeds showed a higher percentage for white-seeded selections, averaging 41.37 per cent. against 38.62 per cent. in the dark-seeded selections. Against this advantage the acre yield of blue linseeds with dark seeds was distinctly higher than those with white flowers.

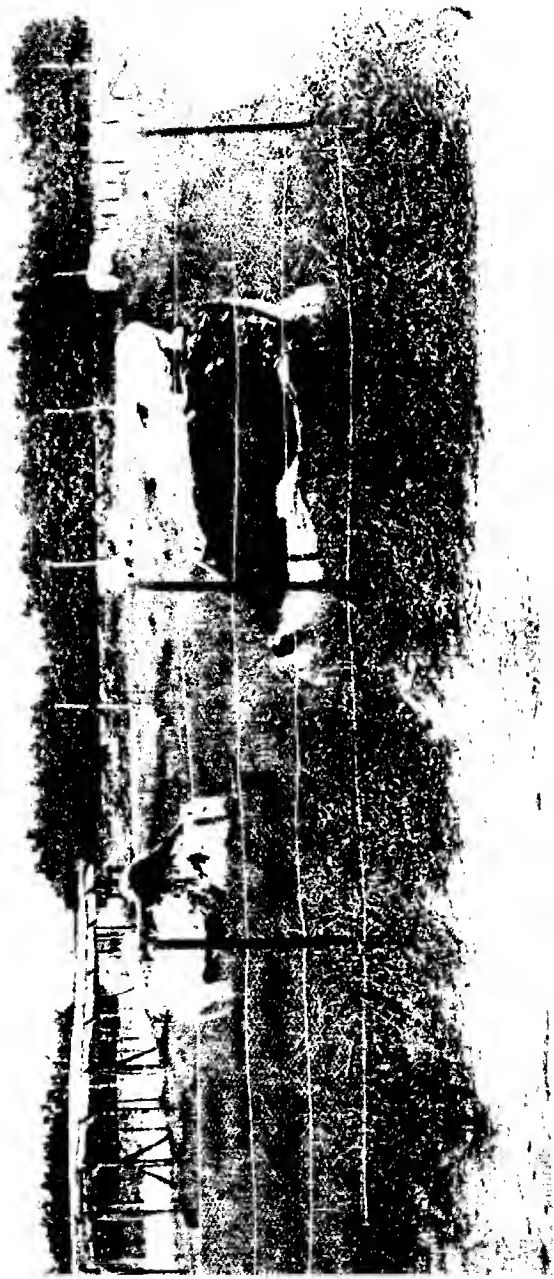
KIKUYU (*PENNISETUM CLANDESTINUM*): A NEW
PASTURE GRASS FOR INDIA.

BY

W. ROBERTSON BROWN,

Agricultural Officer, North-West Frontier Province.

“ HAVE you got Kikuyu ” ? every one asked me as I travelled through South Africa in quest of new plants and agricultural instruction. The botanists told me it had been brought to the Union from British East Africa only ten years ago ; that it was a nutritious perennial running grass of extraordinary vigour, with rhizomes thick as a lead pencil and abundance of broad tender blades. Most remarkable of all was the fact that Kikuyu was not known to have produced seeds. The agriculturists said it was a splendid permanent pasture grass on good land ; that it required an occasional top dressing of manure and, like all other grasses which throw out abundant root stocks, Kikuyu was liable to become sod-bound, and must therefore be cut-up by the plough once in two or three years. Where Kikuyu was established, no other grass could exist in the field. It was drought-resistant in a remarkable degree ; all kinds of stock liked the grass. The horticulturists were no less generous in their praise of Kikuyu than the botanists and agriculturists. Kikuyu was the perfect lawn grass, not for the tennis-court, the hockey, the football or the polo fields, but for breadths of bright green, dense, soft mown grass. On an established Kikuyu lawn, the feet were said to sink in the delicious sward : Kikuyu was a grass to roll on. In the Cape Province, in the Orange Free State, in the Transvaal, in Natal and Zululand I saw Kikuyu at many farms and around public buildings well worthy of the eulogy I had heard bestowed upon it ; but it was at Pretoria in the delightful grounds of the Union Buildings that I first looked on really extensive breadths of Kikuyu. Over all the beautiful



ON KIKUYU: "THEIR HEADS NEVER RAISING".

lawns there appeared to be no weed or grass of any description in the emerald green Kikuyu. It was almost with a twinge of jealousy I saw the loveliest lawns of England rivalled here in South Africa.

On the return voyage to India I carried with me a turve of Kikuyu. Apparently more dead than alive, it was planted in a rich bed at the Peshawar Agricultural Station on 3rd September, 1921. Before the first touch of frost in December, the grass had made extraordinary good growth and covered four square yards of land. A slight protection of branches was then given, and the grass came through the cold months of January and February without suffering more than a check in its growth. In April the runners, rooted and unrooted, were divided into six-inch lengths and planted three feet apart each way on half an acre. In four months' time the area was closely covered by Kikuyu, and sheep and cattle were put to graze on it (Plate IV).

In December the more vigorous, soft runners were injured when the mercury fell to 28°F.; the grass was browned and growth ceased, but Kikuyu was otherwise uninjured. With the first warm breath of spring the grass sprang into vigorous growth again.

Two-thirds of the area has been regularly grazed by the farm stock, the remainder has been allowed to grow that the habit and nature of Kikuyu might be studied.

From the comparative table of chemical analyses quoted below from the *Union of South Africa Dept. of Agri. Leaflet No. 45*, it will be seen that Kikuyu compares very favourably with lucerne and other more well known grasses in this country:—

	Moisture	Crude protein	Carbohydrates	Fat (ether extract)	Crude fibre	Ash	Containing true protein	Nitrogen	Albuminoid nitrogen
Kikuyu (Air-dried)	8.29	12.36	35.06	1.79	33.08	9.42	8.31	19.770	1.330
Kikuyu (Green)	76.09	3.63	9.26	0.51	7.91	2.60	12.22	0.579	0.358
Lucerne (Hay)	8.00	15.50	30.60	2.40	34.80	8.90	..	..	..
Teff (Hay)	8.20	6.00	43.20	1.10	34.80	6.70	..	..	..
Rhodes-grass	9.00	9.20	29.30	1.40	42.50	8.70	..	..	..
Guinea-grass	8.02	9.02	28.61	1.68	40.54	12.10	7.09	1.445	1.134

Kikuyu is worthy of a trial in any part of India where the average annual rainfall exceeds 20 inches, or irrigation is available. As it does not produce seeds there is little danger of the grass spreading to fields whereon it might be undesirable. Kikuyu may go a long way in helping to provide really good nutritious grazing for the dairy cattle in India, for wide sweeps of lawn or for the race course. It is probable that it will prove superior to *dhu!* (*Cynodon dactylon*).

THE PROBLEM OF POTATO STORAGE IN WESTERN INDIA.*

BY

S. L. AJREKAR, B.A.,

Ag. Professor of Botany, Royal Institute of Science, Bombay

(Formerly Plant Pathologist to Government, Bombay, Poona).

THE study of the storage rots of potato has been carried on in the laboratory of plant diseases at the Poona Agricultural College, with some interruptions, since 1917. It is proposed in this paper to discuss the bearing of the main conclusions reached on the problem of potato storage in Western India, the detailed experimental evidence in support of the conclusions being reserved for separate publication.

PREVIOUS WORK ON THE PROBLEM.

The problem of potato storage has always been one of great importance since the introduction of potato cultivation in Western India. Considerable losses in storage occur due to various causes. One of the most recent estimates of such losses made from actual observations on cultivators' stores puts down the loss at between 50 and 75 per cent.¹ The potato moth (*Phthorimæa operculella*) is the most obviously visible of the pests and diseases of the potato tuber, and it is not surprising that it had been for many years regarded as the most important of the potato troubles in Western India. A considerable amount of work was done on it by the Bombay Agricultural Department between the years 1906 and 1912, resulting in the discovery of fumigation with petrol as an efficient and practicable remedy.

The moth trouble, however, is not the only one causing damage in potato storage. Bacteria and fungi, either independently or

* Paper read at the Indian Science Congress, Lucknow, 1923.

¹ Kasurgode, R. S. *Proc. Third Ent. Meeting, Pusa, 1919*, p. 764.

following in the wake of the caterpillar of the potato moth, cause quite considerable, and sometimes even greater, damage. This was strikingly brought out in an experiment conducted by Mr. Ramrao S. Kasargode, Assistant Professor of Entomology, Poona Agricultural College, in 1912, in which it was found that, in spite of fumigation which excluded the potato moth, as much as 55 per cent. out of a lot of 5,000 lb. tubers were destroyed by rotting within a period of three months.¹ The investigation of this particular case of rotting was carried out at Pusa by Hutchinson and Joshi² and led to the discovery of two kinds of bacteria which are capable of invading the living potato tuber under certain conditions and causing it to rot.

The acuteness of the potato storage problem was not, however, fully realized until, owing to the Great War, the import of Italian seed tubers was stopped and cultivators in Western India were awakened to the necessity of becoming independent of foreign supplies in respect of seed tubers. This was the origin of the investigations on potato cultivation in Western India by Dr. H. H. Mann and others, the results of which are published in *Bulletin 102 (1920) of the Bombay Department of Agriculture*. Chapter IX of this Bulletin deals with the storage of potatoes, and the authors (Mann and Nagpurkar) have come to the conclusion that the "vital factor in the potato problem in Western India" is a form of rot which they term "heat rot" and which they regard as identical with the "black heart" described by Bartholomew^{3,4} and Stewart and Mix⁵ in America. The "heat rot" is believed by Mann and Nagpurkar to be caused by mere physical heat and to have nothing to do with parasitic organisms and it is said to occur whenever the temperature of storage rises above 90°F. On the basis of this belief these authors recommended a system of storage⁶

¹ Kasargode, R. S. *Ibid.*

² Hutchinson, C. M., and Joshi, N. V. *Mem. Dept. Agri. Indin, Bot. Ser.*, 1, No. 5, 1915.

³ Bartholomew. Black heart of potatoes. *Phytopathology*, 111, 1913, pp. 189-182.

⁴ Bartholomew. A pathological and physiological study of the black heart of potato tuber. *Centralblatt Bact. Parasit Infect.*, 43 Bd., Nos. 19-24, 1915, pp. 609-639.

⁵ Stewart and Mix. *N. Y. Agri. Expt. Sta. Bull.* 436, 1917.

⁶ *Bomb. Dept. Agri. Bull.* 102, p. 96, 1920.

the essentials of which are (a) fumigation with petrol, (b) rigid sorting to remove injured or diseased tubers, (c) storing in bags in a godown where the temperature is maintained below 90°F., and (d) periodical inspection of bags. It is claimed that by this system "potatoes kept for seed can be maintained without anything like the serious losses which have often, if not usually, been incurred in the past."

In actual practice, however, this system has not been found to fulfil its promise to solve the potato storage problem in Western India. Mann and Nagpurkar¹ give no information as to the actual results obtained in the improved storage house described by them. Presumably, at the time of publication of their Bulletin, no actual storage had been done in the storage house constructed according to their design on the premises of the Poona Agricultural College. The Economic Botanist to Government, Bombay, however, writes in this connection in his Annual Report for 1920-21² that "it has been possible to keep the temperature (of storage) down to an average maximum of 85.9°F. during May by quite crude methods but still there has been much loss in storage. This question needs more study." The rotting material from this storage was examined from time to time in the laboratory of Plant Pathology at the Poona Agricultural College and symptoms of the so-called "heat rot" were frequently noticed, indicating that they might occur at temperatures lower than 90°F.

The need for more careful study of the potato storage rots had also become obvious from the constant association of certain fungi and bacteria, each with characteristic effects, with certain types of rotting in tubers received for examination. Certain striking discrepancies between the descriptions of "heat rot" of Mann and Nagpurkar and those of the "black heart" of American authors also suggested a confusion of causes and effects and necessitated a careful study of the relative responsibility of physical heat and micro-organisms in the causation of potato rots.

¹ *Bomb. Dept. Agri. Bull.* 102, pp. 95-96, 1920.

² *Ann. Rept. Dept. Agri., Bombay, 1920-21, Appendix I, p. 114.*

CONCLUSIONS FROM THE WRITER'S WORK ON POTATO STORAGE ROTS.

The studies just alluded to have been carried out during the past few years by the present writer and the main conclusions reached may be briefly stated as follows: -

(i) The storage rots of potatoes as distinct from the moth trouble may be divided into two classes:—(1) Dry rots caused by fungi and (2) wet rots caused by bacteria.

(ii) Of the fungi, four different kinds were found responsible for potato rots, two species of *Fusarium* and two species of *Sclerotium* (*Sclerotium Rolfsii* and *Sclerotium* sp. hitherto known as *Rhizoctonia destruens* and *Rhizoctonia Solani* respectively). The identification of these fungi is not yet complete.

(iii) Unaccompanied by bacteria, each of the above fungi produces a characteristic form of dry rot, but the individuality of the rot is often lost owing to bacterial invasion and it ultimately becomes a wet rot, especially at higher temperatures (between 86°F. and 100°F.).

(iv) All these fungi appear to attack the potato tuber ordinarily through wounds in the skin. But they may also find admission, though less frequently, through lenticels and through the interruptions in the skin in the neighbourhood of the eyes.

(v) All these fungi grow fairly well between temperatures of 77°F. and 95°F., though the optimum is different in different cases.

(vi) The wet rots are caused by a number of forms of bacteria, and on two occasions (1912 and 1918) on which samples of rotting tubers were sent to the Imperial Bacteriologist, Pusa, for examination, the same or very similar organisms were found to be responsible. These are common soil organisms and as such probably invariably present on the surface of tubers and are capable of causing rots in living potato tubers under certain conditions of temperature and moisture. The optimum temperature for the growth of these is between 86°F. and 104°F.¹

(vii) The "heat rot" described by Mann and Nagpurkar is only a form of bacterial wet rot and the symptoms included in this

¹ Hutchinson, C. M., and Joshi, N. V. *Ibid.*

term, viz., blackening and softening of the flesh of the tuber and exudation of watery matter and foul odour, have been found to occur only in the presence of bacteria. These symptoms are *not* produced when micro-organisms are successfully excluded and heat alone up to 42°C. (107·6°F.) is allowed to act on potato tubers constantly for a period of nine days at least. On the other hand, these symptoms may be produced at temperatures as low as 81°F. when the appropriate micro-organisms are present. Heat by itself cannot, therefore, be regarded as a primary cause of potato rots, as supposed by Mann and Nagpurkar.

(vii) The symptoms described as "heat rot" are quite distinct from those of "black heart" as will be seen by careful comparison of figures and description of the Indian and the American authors.

(ix) There is reason to suppose that continued exposure to high temperatures like 104°F. might eventually kill the eyes and tissues of potato tubers sooner or later and render them liable to attack by saprophytic organisms, some of which are known to become pathogenic at temperatures of about 95°F. It is in this sense that heat by itself might be a primary cause of potato rots. There is also the possibility of an excessive rise of temperature in potato heaps due to respiration and action of micro-organisms, as was found by Cotton and Taylor¹ in potato clamps in England. Mann and Nagpurkar,² however, did not find the temperature rising higher than 93°F. in the potato heaps in Western India with their special cooling arrangements, and it is unlikely that physical heat by itself is a primary cause of potato rots in Western India.

THE BEARING OF THE ABOVE CONCLUSIONS ON THE PROBLEM.

The problem of potato storage in Western India is, in the light of the above conclusions, rather more complex than has been supposed by Mann and Nagpurkar. It is not sufficient to keep the temperature of storage down to 90°F., for at temperatures between 80°F. and 90°F. the organisms found associated with potato rots thrive

¹ Cotton, A. D., and Taylor, H. V. The causes of decay in potato clamps. *Supplement No. 18 to Jour. Bd. Agri., London*, March 1919, pp. 54-58.

² Mann and Nagpurkar. *Ibid.*, pp. 89-90.

specially well. In devising measures against potato rots, therefore, it is necessary to have regard to the biology of the respective organisms concerned and to endeavour to prevent, first, infection by these organisms and, second, their spread. How far this is feasible will now be discussed.

PREVENTION OF INFECTION.

During the course of the work on potato rots one fact was brought out prominently, namely, the existence of a widespread infection of potato tubers with one or more of the rot causing organisms already before the tubers went to the storage house. It has been quite a common experience to find some of the tubers selected as apparently healthy to serve as controls in the inoculation experiments developing one or more of the rot causing organisms during the course of the experiments in spite of all surface disinfection. This experience agrees with that of American workers stated in summary by W. A. Orton¹ of the U. S. Department of Agriculture in the following words :

“ We are coming to realize more and more..... that we have to deal primarily with a condition of general soil infection and that the planting of healthy seed is by no means an insurance of a healthy crop.”

Although the corky skin of the potato tuber, if uninjured, ordinarily prevents the entry of pathogens successfully, still there are solutions of continuity of the skin in the neighbourhood of the “ eyes ” and in the innumerable lenticels which occur on the potato tuber and afford points of entry to rot causing organisms, which are present in the soil. Hence the widespread infection already present in the tubers before they go to the storage.

To prevent this kind of infection, extensive sterilization of the soil would be necessary, but apart from the expensiveness of soil sterilization, any method of sterilization by heat or by use of poisonous substances would probably destroy the useful

¹ New work on potato diseases in America (paper contributed to the International Potato Conference, London, 1921).

micro-organisms along with the harmful ones and what might be gained in freedom from diseases might be lost in fertility.

Future work on this subject, therefore, must be directed towards finding out the best methods of controlling soil infection by cultivation methods and by the study of crop rotations. At present it must be admitted that we do not know of any satisfactory methods of preventing infection of potato tubers in the soil.

PREVENTION OF SPREAD IN STORAGE.

In the prevention of spread in storage, two lines of attack are feasible. One is to destroy the rot causing organisms in and on the tubers before putting them in the storage and the second is to so arrange the conditions in the storage house that the organisms would find them unsuitable for growth and spread. Various fungicides have been tried with varying degrees of success depending on the extent to which the tubers had been already infected before the treatment. In general, it may be said that while fungicides like copper sulphate, mercuric perchloride and formalin are effective to some extent in destroying the organisms at or near the surface of the tuber, not one of them is capable of ensuring perfect sterilization, if the organisms have already penetrated to some depth below the surface. Hutchinson and Joshi¹ recommended the treatment of seed tubers with copper-sulphate solution (2 per cent. for 30 minutes); and in their own experiments they seem to have got results which indicate the effectiveness of this fungicide in preventing infection by rot causing bacteria, especially when care is taken to remove all injured tubers and the moisture in storage is kept at a low degree. But in both Mann and Joshi's² experiments and in our own, it has been found that surface sterilization with copper sulphate has not been sufficient to prevent rotting in every case and the same experience was obtained on a fairly large scale by Mr. Ramrao S. Kasargode, Assistant Professor of Entomology, Poona Agricultural College, in the hot weather of 1913 when he

¹ Hutchinson and Joshi, *Ibid.*

² Mann and Joshi. A chemical study of heat rot. *Appendix to Bom. Dept. Agri. Bull.* 102, 1920.

stored about 4,000 lb. of tubers after treatment with copper sulphate in thin layers on racks in a well ventilated room. Practically all the tubers showed the characteristic bacterial rot. Still the method suggested by Hutchinson and Joshi may be found useful by potato growers who wish to preserve a small quantity of seed tubers for their own use, especially if practised immediately after harvest, before the micro-organisms have had a chance to get inside the tubers and beyond the reach of the fungicide.¹ Formalin treatment cannot be recommended, both because it will be more expensive and because its effect is not likely to be so lasting as that of the copper sulphate treatment. Mercuric perchloride is a dangerous poison and as it has been shown by Güssow and Shutt² that 3 lb. of potato tuber (13 tubers) treated for 3 hours with 1 : 2,000 corrosive sublimate solution will take up from the solution 0.05 gm. of HgCl_2 , which is six times the maximum official dose in medicine, potatoes so treated must become non-edible. For this reason, as also for the ineffectiveness of even this powerful fungicide against organisms already inside the potato tuber, the use of mercuric perchloride in preventing potato rot cannot be recommended.

As regards controlling the conditions of storage so as to reduce the chances of growth and spread of organisms already present and to prevent infection, the knowledge we have gained of the physiology and parasitism of the rot causing organisms indicates the methods likely to be successful. It is common-place to say that potatoes or, for the matter of that, anything liable to rot, must be stored in a cool, dry and well ventilated place. Of these conditions of storage the temperature is perhaps the most important and is so recognized by cultivators, who have devised elaborate arrangements to bring about a reduction of temperature of storage. One such method in vogue in the Khed Tahuka of Poona District has been described by Mann and Nagpurkar³ by which the temperature can be kept at from 86°F. to 93°F. This method has been improved

¹ The importance of immediate (i.e., within 24 hours after digging) disinfection of potato tubers is brought out by O. A. Pratt's trials with HgCl_2 and formalin in the control of the powdery dry rot of potatoes caused by *Fusarium trichothecioides*. *Jour. Agri. Res.*, VI, 830, 1916.

² Güssow, H. T. *Canada Expt. Reports*, 1912, pp. 200-202.

³ *Bombay. Dept. Agri. Bull.* 102, pp. 33-34, 1920.

upon in the storage house built by Messrs. the Union Agency of Bombay in their potato works on the premises of the Poona Agricultural College.¹ The temperature in this has been kept as low as 82°F. and the ventilation is also much freer than in the ordinary cultivator's storage. But both these methods of storage have the disadvantage of a high degree of moisture which is an inevitable result of the use of evaporating water in each of these methods as a means of reducing the temperature; and although, under favourable conditions and with good care in the sorting preliminary to storage, very good results have been occasionally obtained, reducing the loss due to rots to as low as 2 to 5 per cent.,² yet these good results are not obtained with certainty and serious losses may occur even in such methods of storage. Such success as was obtained in these storages would seem to be due to the careful sorting out and rejecting of infected and injured tubers and not to the temperature of the storage. For, while the low temperatures reached seem to keep some of the wet rot causing bacteria fairly under control, these same temperatures are found most suitable for the growth of other organisms, particularly the fungi *Fusarium* sp. and *Sclerotium Rolfsii*. This explains the observation of Mann and Joshi that, with a temperature of storage below 85°F., "the attack of *Fusarium* dry rot went on increasing."³ and the experience of Mann and Nagpurkar that "storage in Poona in the cold weather for two months at about 85°F. means the loss of over 89 per cent. of the stored potatoes (in some cases)."⁴

Further experiments with methods of storage would seem, therefore, desirable, and in conducting these the temperature and moisture relations of the various organisms will have to be borne in mind. It has been found that the dry rot *Fusarium* fungus and the fungus *Sclerotium Rolfsii* grow best at temperatures between 25°C. and 30°C., but that they also grow fairly well at the lower temperature of 20°C.; this would suggest that the temperature of storage must be at least reduced to 20°C. Indeed American writers⁵

¹ *Ibid.*, pp. 95-96.

² *Ibid.*, p. 95.

³ *Ibid.*, pp. 92-93.

⁴ *Ibid.*, p. 67.

⁵ Pratt, O. A. Control of the powdery dry rot of Western potatoes caused by *Fusarium trichothecioides*. *Jour. Agri. Res.*, VI, 1916.

recommend as low temperatures as 2° to 4°C. to prevent losses from *Fusarium trichothecioides*, which is a dry rot fungus very similar to, if not identical with, our own dry rot *Fusarium*. If such low temperatures are found absolutely necessary to solve the potato problem of Western India, then the cold storage methods in Western countries will have to be adopted in this country also.

It seems doubtful, however, if the resort to cold storage would pay in connection with a crop which covers only about five or six thousand acres in Western India, which is used as a more or less fancy vegetable and not a staple article of diet, and which is generally sold off by the growers immediately after harvest. The losses in storage, so far as they occur, are easily made up by the potato merchants by increase in price, which, in that case, affects only a comparatively small section of well-to-do buyers in a few big cities. Even in Germany¹ where the potato crop in 1912 covered an acreage of 8,165,000, and where it forms not only an important staple crop for stock feeding and human consumption, but also an important raw material for certain chemical industries, a 10 per cent. loss by decay which occurs every year on an average is apparently considered negligible. If, therefore, by the systematic and continued use of the comparatively simple precautions, namely, (1) rigorous sorting, fumigation and rejection of all diseased and bruised tubers, (2) careful storage in bags, (3) keeping down the temperature of storage below 90°F., the losses can be kept down below 10 per cent. as has been claimed by Mann and Nagpurkar,² cold storage would seem unnecessary for the conditions in Western India. The removal of injured and infected tubers in the preliminary sorting would considerably lessen the chances of subsequent infection in the storage, the rot producing fungi being ordinarily wound parasites. These precautions together with improvements in the storage house designed to reduce the temperature without increasing the moisture should enable us to finally solve the problem of storage of potatoes in Western India.

¹ Orton, W. A. *U. S. A. Dept. Agri. Bull.* 47, 1913.

² *Ibid.*, pp. 108-109.

PROTECTION OF CABBAGE AND KNOLKHOI SEEDLINGS FROM FLEA-BEETLES.

BY

P. V. WAGLE, B.AG.,

Entomological Assistant, Konkan.

THE growing of vegetables for the market, and particularly the cultivation of cabbage, knolkhoi and other similar plants, is beset with many difficulties, but there are few which are more annoying and injurious than the way in which the young seedlings are destroyed in the seed-beds by several insects, of which by far the most important are the flea-beetles. The present note deals with experiments made in the Konkan near Bombay to check the damage from these and similar pests.

The flea-beetles are small bluish-coloured beetles, which, being furnished with powerful hind-legs, jump when disturbed almost as vigorously as fleas, from which faculty their name is derived. There appear to be many species of these in India, but most of them have not been identified, and about their life-history little is known. As the seedlings of many vegetables grow these beetles are often found in multitudes feeding on the leaves and leaving behind them numerous small round holes. The tender seedlings so attacked generally die.

The measures previously adopted against these and similar seedling pests have chiefly consisted in collection of the insects by hand, spraying with kerosine emulsion and dusting of the plants with ashes previously treated with kerosine. Such remedies were tried in the present experiments but, when the pest was bad, none of them was satisfactory. Spraying and dusting of seedlings in seed-beds is in any case not very satisfactory as the frequent

necessary watering tends to remove the materials from the leaves. When the insects are present in large numbers, collecting by hand or bag proved almost impracticable.

Two new methods were therefore tried. As the area of seedlings is usually small, it was suggested that the whole of the seedling area should be enclosed by a fine-meshed curtain like a mosquito net. Two seed-beds, each three feet square, were prepared and sown with knolkhol seed. One was completely protected by a curtain as described fixed on a bamboo frame, and about eighteen inches high. The lower sides of the curtain were weighted down with stones. The net was easily removed for watering and was then immediately replaced. The result was excellent. No attack took place, while in a similar seed-bed without protection the plants were miserable, stunted and several times smaller than those inside the net. The inevitable interference with the light inside the net did not seem to have any serious effect on the character of the seedlings after transplanting.

The second method tried was by trapping the flea-beetles on a sticky plate. It was suggested by the success which had been obtained in trapping mango-hoppers on trees by means of a sticky mixture of oil and resin. A rectangular tin plate, two feet long and eighteen inches wide, with a handle at the back for holding, was used in the present experiment. This was painted on the lower side with a sticky mixture prepared from boiled *undi* oil (*Calophyllum inophyllum*) (1 part) and fairly powdered resin ($2\frac{1}{2}$ parts). Any other similar oil would probably have given the same results, but the proportion of resin necessary to keep the mixture sticky would have to be worked out in each case. The tin plate so prepared is held over the infested seed-bed, and the plants gently brushed. The insects when disturbed fly up and are caught on the sticky tin plate. If this brushing is repeated on four or five successive days, the infestation can be almost entirely removed. If necessary, it can, of course, be continued longer. After three or four days, the sticky mixture dries up, but a few minutes' exposure to the sun will make it as sticky and effective as before. The experiments with this method turned out a complete

success and the damage by flea-beetle was reduced to very small dimensions.

In actually carrying out the first of the methods above suggested, a kind of coarse woven cloth, locally available in the market, was found to be satisfactory. A piece ten feet long and thirty inches broad cost about a rupee. Three such pieces will cover a seed-bed covering forty square feet, the cost for making the complete net being only eight annas. Thus at a cost of Rs. 3-8-0 a seed-bed will be protected sufficient to plant out one-eighth of an acre and the curtains will last for four or five years. This will save an annual large loss in these expensive vegetable seeds, with a guarantee that the seedlings will be ready when wanted.

The second method will only cost eight annas for making the tin plate with four annas for the mixture. By the use of this it is possible to clear seed-beds sufficient to plant out one acre of cabbage or knolkhol.

A FEW OBSERVATIONS ON PADDY (*ORYZA SATIVA*) CROSSING.*

BY

S. G. SHARNGAPANI, B.A.,

Offg. Economic Botanist, Bengal.

THE paddy spikelet or flower offers some difficulties in successful crossing. Experience showed us that special methods must be employed in successfully crossing it. As a result we gradually evolved a method which is now nearly cent. per cent. successful. To understand the difficulties and to learn how they have been overcome, one must first learn the mechanism of the paddy flower.

The paddy flower is composed of two short empty outer glumes usually not more than one-third the length of the inner glumes. They are of no account in paddy crossing, for they neither help nor retard the crossing in any way.

The inner glumes are generally two in number and though not differing from each other in size and texture, one of them (the third as it is called) is five-nerved and bears at its apex an awn in all awned varieties of paddy. The other (fourth glume) is three-nerved and when removed bears away with it the ovary, the stigmas and a few of the stamens. The two inner glumes between themselves enclose the paddy grain. Inside the inner glumes are two broadly oval, small, thick, fleshy bodies, the lodicules. They play an important part in the opening of paddy flowers.

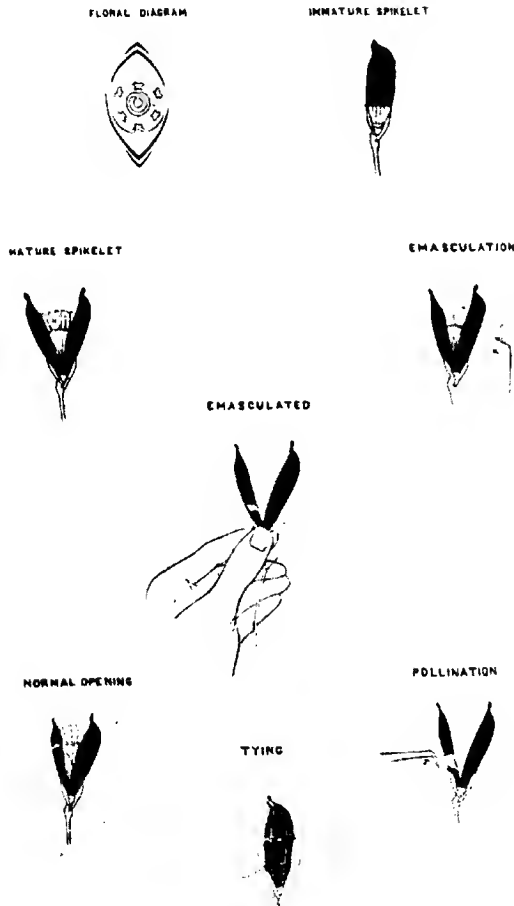
The stamens are six in number. All are well developed fertile and functioning. In a mature spikelet held to light, they are seen to occupy about half the length of the entire spikelet.

The ovary is unicellular†, a little longer than broad, smooth, and bears at its apex two styles with feathery stigmas.

* Paper read at the Indian Science Congress, Lucknow, 1923.

† In the double-rice paddy, however, the ovary may be bi-, tri-, or quadri-cellular, the number of styles then becoming double the number of cells present in the ovary.

The mistake that one is likely to make in crossing paddy is to consider the glumes as functioning the same as they do in the



case of wheat. In crossing wheat the glumes are usually snipped off with a pair of fine scissors before emasculation. The same

procedure cannot be followed in the case of paddy, because the glumes are delicate, protective in function and form a part and parcel of the mature seed. If they are injured in any way likely to set up withering, the seed does not set.

Paddy anthers usually burst just a little before the flower opens. We found by actual experience that emasculation must be done at the latest two hours before the flower opens. The two glumes are very gently pulled apart with fingers—no forceps should be used—and the stamens removed with a pair of fine bent forceps. About two hours later when paddy flowers begin to open, the emasculated flowers are pollinated and the glumes are closed and tied up with a piece of fine silken thread. The tying helps to keep the glumes in their natural position. If the glumes are not tied up, they do not close properly and the percentage of successful crosses diminishes greatly. The tying up also does the work of bagging and no further bagging is necessary.

The time at which the flowers open differs with the time of the year when the paddy plant flowers. For instance, *aus* or early paddy, which is sown in April-May and flowers in July-August, opens at about 7 a.m., while the *sail* or transplanted paddy which flowers in October opens at about 9 a.m. Weather conditions at the time of flowering affect a good deal the time of opening, sunshine hastening the process and clouds and rain retarding. It has been found possible to cross the *aus* with the *aman* or *sail* paddy and the *aman* again with the wild paddy, and some of the resultant crosses are yielding very interesting results. If it is intended to cross *sail* paddy with *aus* paddy under ordinary field conditions, it is more convenient to grow the *sail* paddy in its proper season, and to grow the *aus* paddy out of its season, for the *aus* can be made to grow and flower during the *aman* season while the *sail* paddy cannot be made to flower during the *aus* season. In crossing with the wild paddy it is important that the *sail* paddy should be used as the female parent and the wild paddy as the male, because the wild paddy spikelets shed before the grains mature. If the wild paddy is used as the female parent the crosses are shed before they are ripe, and are thus lost.

Selected Articles

METHODS OF PLANT BREEDING IN GENERAL.*

BY

NEMESIO MENDIOLA, B.S.A., M.S., PH.D.,

Consulting Plant Breeder, Bureau of Agriculture, and Associate

Professor of Agronomy, College of Agriculture, Los Baños.

UNDERLYING improvement of different crops are some fundamental processes. These do not vary, essentially, when applied to individual kinds. Variation lies merely in details which are learned only through experience. Given a basic understanding of the essential phases of plant breeding, one should not find it hard to develop a method of improvement applicable to a particular kind of material.

Methods classified.

The various methods of plant amelioration may be classified under three main groups: namely, (1) selection, (2) hybridization, and (3) hybridization combined with selection.

(1) SELECTION.

Too often, the term, "selection," as a method of improvement in Genetics, is confused with other processes to which selection is popularly applied. For example, it has been taken to mean varietal selection, that is, the choice and use of the best variety. Varietal selection within a species is indeed expedient especially when thousands of varieties exist. For, the elimination of those varieties which are not profitable to raise will improve the average yield of the varieties or the species. However this does not fall under genetic selection. Neither does selection mean in cereal

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improvement the selection of the largest or the heaviest seeds although, again, it must be said that increased yield may be obtained by such a practice, for, in whatever way the biggest or the heaviest seeds be obtained—by hand picking or by the use of a fanning mill or by soaking the seeds in a brine solution where only the heaviest will not float, thus allowing their separation from the lighter ones—the seeds are freed from broken individuals and weed seeds. Weed seeds in the seed mean more expense in weeding and cultivation of the field, less moisture and food for the plants, and less yield and money for the farmer. Also, the larger and heavier seeds contain more stored food material for the embryo than the lighter and smaller ones, and under unfavourable conditions they are more likely to survive. Except these advantages, it is very doubtful, as far as yield is concerned, if the large and heavy seeds have any superiority over the smaller and lighter ones.

It should be borne in mind that seed selection, as the term is used in Genetic literature, does not mean just selecting seeds, which are free from disease or other physical defects. True, the use of no seeds but those disease-free is to be preached, indeed this must be the practice on every farm, for it may happen that the disease on the seed will appear on the plant which grows therefrom. This would mean a diseased field which means poor yield and a loss to the farmer. But even when only the best variety is grown, and only seeds which are free from broken grains, from weed seeds and from diseases are used, there remains the fact that the yield may be poor, unless genetic selection, or strain selection, is practised.

The reader doubtless knows the meaning of the sayings, “It is the blood that counts,” and “One is of bad ancestry.” We can just as truly say, “It is performance that counts.” When we desire to improve a given variety of plant by improving its yield through selection, what is really desired is to free a given stock from such blood, or strains as is responsible for low yield, and to obtain only plants that are high and superior yielders. But it is usually impossible to tell from the appearance or from the size or weight of a seed whether the plant which it will produce will

be a poor yielder or a heavy yielder. In a given number of seeds from unselected plants, a plant from a large seed may actually yield less than a plant from a smaller seed. The appearance of seed should serve only sometimes as a guide in the selection of initial parent plants. The appearance of the plant does not always tell what kind of yield its progeny will give. Under certain circumstances, such as when a plant has more fruits than another because of more favourable soil conditions, the progeny of this more favoured plant, on account of less fertile soil, may actually yield less than that of the poorer looking individual. Since neither the appearance nor weight of a seed nor of the plant will tell us exactly what kind of yield the progeny will give, the final judgment of the yielding power must be based on the ancestry of the seed or plant or on the plant's performance--on what it actually does. An example may make this point clear. Suppose, to improve the Filipino race it is desired to enact immigration laws that will prevent the entrance of feeble-minded strains into this country. These laws will prevent admission of immigrants which are feeble-minded, assuming that in this way the "blood" which carries feeble-mindedness will be excluded. But this assumption will not always hold good for even if one be not feeble-minded, he may be a carrier of defective germplasm which bears the determiners for feeble-mindedness and, if allowed to reproduce, may in time be the parent of feeble-minded children. The prevention, therefore, of the entrance of feeble-minded "blood" into the Islands could not depend only upon the appearance of the incoming immigrant but also on his ancestry, just as the hereditary yielding capacity of a grain or seed is best judged from the performance of its parent plant. In brief, then, proper selection is to be based not on appearance alone, but on performance also. This being true, to get any maximum improvement of the yield of a variety ultimately consists in the isolation of the *best single* strain in that variety.

Selection may be of different kinds: (a) mass selection, (b) line selection, (c) clonal selection, and (d) bud selection.

(a) In *mass selection* we proceed somewhat as follows: Bearing in mind the object of the selection, individuals are selected on

the basis of this object and then are planted in a mass. Selection must be made intelligently, in the manner and at such time as will insure the best results. Oftentimes, this cannot be done except in the field when the crop is mature. We may illustrate this with corn. If the object of selection is to improve the yield, intelligent selection of seed ears is not made in the pile, for here we have no way of knowing which ears come from high yielding strains and which come from the inferior sorts. Sometimes superficial examination is sufficient to enable one to choose the desirable individuals. Sometimes, however, different methods of analysis are employed to decide which plants are to be selected and which are to be discarded. Chemical and other analyses are used; also the scale and balance; and the performance record is kept for several years.

For mass selection to be of the greatest value it must be continuous until the limit of improvement is reached. For purposes of demonstration or to determine if any progress and how much is being made, it is necessary to plant a check side by side with selection. The check consists of a portion of the original material. The material left after selection does not serve as a proper check, neither does a portion of the material from which the inferior strains have been taken away constitute a proper check.

In the absence of check cultures, the progress of selection may be determined by comparing the performance of the selected crop with the average performance of the variety for five or more years in the locality or region. When one is familiar with his crop and soil, it may be possible for him to tell when he is getting any improvement even if either the direct or the indirect check for comparison is lacking. However, this is true only under average conditions. If for any reason the crops suffer from unfavourable conditions and become abnormal, then it will be difficult, if not impossible, to diagnose progress.

When check cultures are run at the same time as the selection tests, one point should be borne in mind, and that is genetic contamination. The selected plantings should not be allowed to cross with the check or with any other material. For this reason it

is advisable to carry out the selection cultures in an isolated field and to screen them from the check by planting border plants several rows deep. These plants may be of the selection itself, in which case they should be discarded after harvest, or they may belong to another but faster growing species. Whatever is used, the screen must be effective. With tobacco, contamination is prevented by producing the seeds under bags.

When the plant is self-fertilizing and is not subject to any amount of cross-breeding, the precautions given above are unnecessary.

It should be emphasized here that in selection, the individual plant is the unit. This point is likely to be overlooked under certain circumstances. For instance, when several seeds of a crop are planted in a hill, the hill is sometimes taken as the unit. It is evident that, in so doing, the choice of individuals becomes a hit-or-miss affair. This is well illustrated and discussed fully under mass selection in rice.

The improvement in mass selection is obtained slowly and in this respect it is inferior to line selection. It has the advantage, however, of being practically non-technical and hence easy to use. Mass selection has been used with cotton, and with rice, corn, and other cereals.

(b) *Line selection* consists in the testing of the progeny of single individual plant. Le Couteur and Shirreif were the first to use this method. The progeny test was specially used by Louis Vilmorin and line selection is sometimes called the "Vilmorin Method."

The initial selection of plants in line selection does not differ at all from that of mass selection. Generally, however, fewer individuals are selected in line selection. The critical difference between the two methods is that in line selection the progeny of each selected parent plant is tested separately. The method of planting is often termed "head-to-the-row," "plant-to-the-row," or "ear-to-the-row," meaning that the seeds from one single head, plant, or ear are planted in one row. Not all the seeds from one plant need be planted, only sufficient to give a fair sample. One

hundred offspring are generally sufficient to represent the strain. When about 100 seeds are sown in a row, the method of planting is termed "cent-gener method." This was first used by Hays of Minnesota in grain breeding.

Each year, the most promising lines or strains are saved and tested. This is done until the few really superior sorts are discovered, or the best single sort, then the seeds of each line may be multiplied as fast as possible and introduced into the seed trade or into the general farming. The critical point in line selection is the isolation of the best single strain. It were better if we called the process, isolation. Strictly speaking, no further selection is necessary if the isolation is done properly. Of course, care must be taken that no seed of inferior race contaminates the improved stock.

Line selection has been the important method of plant improvement followed in the Swedish Seed Station at Svalof. Here the method came to be known as the "System Pedigree" or "Separate Culture."

Line selection is easily applicable to naturally self-fertilized plants or to those reproducing vegetatively. Among them there is practically no out-breeding. When applied to naturally cross-fertilized plants, selected parent plants should be guarded and prevented from crossing with any other plant in the same row or in another row. Either mechanical or genetic contamination by inferior strains will cause a gradual loss of improvement in proportion as the seeds of inferior quality supplant the improved ones. Moreover, the selected plants should be self-pollinated.

(c) *Clonal selection.* The term "clon," from which the adjective "clonal" is derived, is applied to a pure line produced asexually. We may conceive of a population consisting of a mixture of different clons (sometimes written "clones"). Improvement in this kind of population will be obtained by isolation or selection of the best clons or the best one of them. Within a clon itself, as within asexually produced pure line, heritable and desirable variations may arise and selection within this pure line will have for its object the isolation of those variations.

Common examples of clons are found in fields of potatoes, of abaca (*Musa textilis* Nee), of plant canes (distinguished from seedling canes), of ordinary plantings of cassava and pineapple.

(d) *Bud selection* is closely related to clonal selection. Bud selection has been used mainly in fruit improvement. It is generally known that bud mutations or bud sports occur in fruit trees. Many important commercial varieties of fruit existing at the present day originated as bud sports. The Washington navel orange is a familiar example.

In the Philippines, bud selection has a promising future. We practically have no seedless variety of any pomological crop. We are looking ahead to the day when one may eat the delicious lanzon without having to be bothered with its bitter seed. We anticipate similar improvement with mango, mabolo, and other fruits. Bureau of Agriculture officials verbally claim that there is now a seedless *dulat* (*Eugenia jambolana* Lam.) variety which is in the way of propagation.

(2) HYBRIDIZATION.

Objects. Hybridization is performed with one of three main objects in view. These objects are: (a) To bring about increased variability, that is, to "break the type"; (b) to get a combination of certain desirable characters; and (c) to obtain increased vigour which is supposed to be due to heterosis, or the heterozygosity of the hybrids.

Aspects. When the object of hybridization is to test or further study any or all of the phases of the Mendelian laws of heredity or to obtain hybrids from parents of known purity it is a purely scientific aspect. In this kind of work control of parentage is important. Because the operation is quite technical and consumes a good deal of time, it cannot be done on a commercial scale.

Hybridization has also been performed for a purely commercial or utilitarian reason and without strict adherence to scientific precedents and procedures. The work of Burbank, of which more will be said later, as well as the work of horticulturists are good

examples of this phase of hybridization. For convenience, I will designate this kind of work as commercial hybridization.

Technique of hybridization (purely scientific). A prerequisite for this work is familiarity with the sexual group of plants and the pollination habits of the flowers.

Generally, plants may be classed under three groups: (a) Dioecious, (b) monoecious, and (c) hermaphrodite. In dioecious plants, one sex is in one individual, while the opposite sex is in another. It has become a custom to call the plant carrying the male sex, a male plant; and the female sex, a female plant. We have, for example, a male *papaya* (*Carica papaya* L.) tree and a female *papaya* tree. If a plant carries both sexes and if one sex is not functional or functions at a different time than the other, it is, for all practical purpose, a one-sexed individual. We find an example of the first case in *papaya* also, and of the second in *Musa textilis*. (b) In the monoecious group both sexes are in the same individual but in different parts of the plant. Corn and cucumbers are good examples of monoecious plants. (c) When a plant possesses both the male and female sex organs in the same flower and when both sexes are functional, it is said to be hermaphroditic plant or to be a hermaphrodite. Many of the cultivated crops belong to this group.

Besides a knowledge of the groups described above, a hybridizer must know a number of other points about the flower. These are: (1) Structure, (2) relative time of maturity of stamens and pistils, (3) the quantity of pollen necessary for a good setting of seeds, (4) the length of time at which the pollen remains viable, (5) the amount of injury the female flower will stand, (6) whether the flower is self-fertilizing exclusively or whether it admits of a certain amount of cross-fertilization, (7) conditions of the pistil when fully ripe or receptive of pollen, (8) approximate length of time from pollination to fertilization, (9) the relative position of male and female flowers in the same tree, or of the male and female parts in the same flower (whether the anther is above the pistil so that the pollen drops naturally upon the stigma or whether it is below, necessitating some pollinating agent), (10) the number

of anthers, (11) manner and time of dehiscence of pollen, etc. Some of these points may be learned before starting hybridizing work, while others are found out only through experience.

It should be emphasized that, in careful hybridization work, the essential thing is to control parentage absolutely. Hybridization may be further explained by giving specific procedure with different groups of plants.

With dioecious plants, there is selected one plant for female and one for male. Certain buds of these plants are selected and bagged. It is preferable that these buds should be of the same age. The reason for bagging the buds is to protect them from foreign pollen. For most accurate work, it is always necessary to bag the male flowers as there is always the chance of insects visiting the flowers after they have been on other flowers. This is not imagination; in very careful bagging work contamination of pollen has been known. With monoecious plants the male and female clusters are bagged separately.

With perfect flowers, that is, with hermaphroditic flowers, the procedure is somewhat different. Here, emasculation, that is, the removal of male parts to render the flower essentially female, is practised. Emasculation must be done some time before the pollen matures, that is, during the bud stage. After deciding on the parent plants that are to be used, a few buds are picked out on the female plant. All other buds and flowers likely to be included by the bag are removed. Even a single bud left in the same bag with the emasculated flower may spoil the work, as the pollen from the non-emasculated flower is almost sure to come out and settle on the stigma of the emasculated one. With a pair of small forceps, the floral envelope is cut off on one side. In some cases the top portion may be cut off or even the whole perianth may be removed without causing injury to the flower. In fact, it is advisable in some cases to remove the whole corolla. However, some flowers are so sensitive that any great injury done them will prevent the setting of seeds. Experience alone will tell what flowers are thus sensitive and what flowers are not. After cutting the floral envelop either in part or in whole, the forceps are thrust into the flower

and every single anther is removed. Every single anther must be removed for, if any anther is left, it will produce pollen, a condition to be avoided. It is not advisable in this process of removal of anthers to hold the anthers themselves, for in doing so there is always a possibility of breaking the pollen sac, and when this takes place, some pollen grains may drop and later mature. As soon as all anthers are removed, there remains essentially a female flower, but at this stage, it is not yet ready for pollination. So it is bagged and left for three or four days, even a week, for the stigma to develop to the proper age. The flower is tagged. On the tag some symbols are written which will show the date of emasculation and what treatment is to be given, and about when it will receive this treatment. The tag may include with what parent plant it will have to be crossed. For bags there are used small bags which will remain waterproof for several days.

At the same time that the female flower is bagged the male plant is selected and some buds are bagged without previous emasculation. As with the female flower all other flowers are removed as these may have some foreign pollen brought to them.

The length of time from pollination to fertilization depends on the condition of the bud and the weather conditions. Cloudy days delay pollination while bright days hasten it. At least 24 hours are usually needed.

When the male and female parts are ready for pollination can be told by their colour. They usually become darker, also viscid and sticky due to secretion of different sugar solutions by the cells. When they are ready the male parts are brought to the female; the bag of the female is removed very carefully and the pollen is rubbed on the stigma.

Some plant breeders make it a practice to use a watch glass for holding pollen and a camel's-hair brush for transferring pollen from the glass to the stigma. These helps may be all right if only one kind of pollen is to be used; if several kinds are used, the glass and brush may be sterilized by dipping them in alcohol. But the risk lies in the sterilization not always being thorough.

After pollination, the female new pollinated flowers are rebagged and a record is then taken. The flowers are left bagged until danger from contamination is over.

If fertilization takes place can be told from the discoloration of style and stigma. When the stigma has wilted, the bag may be removed and, after this, the rest of the work is simply taking care of the fruit or seeds until they are ready to harvest. If the flowers are of such a nature that there is danger of losing the seeds by bursting, the flowers or ovaries are kept in a kind of a cage.

After harvesting, the seeds are taken good care of in drying and storage.

When these seeds are planted, the resulting plants are the F_1 plants. At the same time the seeds are planted some parent plants are self-pollinated and plants grown from the self-pollinated seeds for comparison. If the offspring of the self-pollinated parents show great variability, the F_1 plants are to be discarded.

It is a good plan to make back crosses of both parents, that is, to use pollen of each and pollinate flowers of the F_1 plants. The bulk of seeds F_2 will come from self-fertilized F_1 . Sometimes, plants have flowers which are self-fertile. In other cases artificial pollination is necessary.

Records. Keeping records is so important that some plant breeders spend more time in record keeping than in actual handling of the plants. The following points should be recorded not only on the tag or label left with the plant but also in the record book: Date of emasculation; the number or designation of the male parent; and the date of pollination. In the record book should appear, also, a record of the male and female parents and a description of such characters as are involved in the study.

The hybridizer's working outfit. For general purposes the tools herein named are needed. A small good-powered hand lens to use in examination of small floral parts and a small pair of scissors with slightly bent blades about two and one-half centimeters long. For very small flowers, a small pair of surgeon's scissors with blades about one centimeter long is very convenient. Forceps are useful in removing petals and anthers. Small containers for pollen and

some moist chamber for keeping pollen in a moist condition should form part of the outfit. Small-sized merchandise tags and small-sized camel's-hair brushes may be added.

The nature and pollinating habits of the flowers often determine the special tools to be used. There are flowers such as of the alfalfa, which are bound to be pollinated while handling them. The emasculation of this type of flowers has caused so many plant breeders to devise special tools for the process. Information along this line is well given by Oliver (1910) of the United States Department of Agriculture.

The choice of material for bagging entire plants is sometimes a problem to the breeder, and the following suggestions by the Howards (1920) may be useful. They claim that when they got the best results they used cylindrical muslin covers in the Botanical area at Pusa. The covers were on frames consisting of thin bamboo rings. For most purposes the cylinders need not exceed a length of 75 centimeters and a diameter of 30 centimeters; this size may be varied according to the object to be bagged. The advantage claimed for this kind of cover is that it allows a great percentage of setting. The muslin covers are easily washed after use and they last for two seasons. It is said, also, that no case of cross-fertilization have been detected through their use.

The preservation of the viability of pollen is another problem which is met with when the pollen has to be shipped a long distance as from one country to another. The viability of grape-fruit and tangelo pollen has been preserved for six weeks after the poll grains were gathered, permitting them to be sent from Florida to Japan. The method used in this drying was reported by Miss Kellerman (1915) as follows:

* * * Anthers in dried vacuum glass tubes, i. e., tube filled with 1—2 inches, cut $\frac{1}{4}$ inch, exhausted to about 0.5 mm. pressure in the presence of sulphuric acid, the tube is sealed. As far as practicable the pollen was kept at a temperature of 10° C. until sealed.

Commercial hybridization. The best example of this work is that of Luther Burbank of California whom some people call "plant wizard," a name which Burbank, however, regrets being applied to him.

The life and the work of this wonderful worker is described by Hardwood (1919) in a book.

The following quotations from this book will give a very helpful idea of the method with which Burbank has been able to accomplish his very well known work :

Instead of one or two experiments underway at the same time he may have five hundred at once, all requiring constant supervision, many of them extending over a period of perhaps ten years before they come to fruition. Instead of having a few square feet of ground or a few pots under glass, he uses acres of ground, if necessary, in a single test. In place of contenting himself with a half dozen, or even fifty, plants, in making a given test, he uses if necessary a million, all of them pressing forward in a million similar ways toward the same end. And out of the million he saves perhaps in the last sifting but one, and that one the best of all.

* * * He is confined to no one species nor to any one line of combinations. The whole world is his field, and he makes his selections and forms his combinations in absolute disregard of all precedent. The end in view is the point, how to reach it most directly. It may be along so-called scientific lines, it may be in absolutely new and original paths—more likely the latter—but the means are the non-essentials, the end is paramount.

Hardwood quotes the following advice and warning from Burbank :

The plant breeder, before making combinations, should with great care select the individual plants which seem best adapted to his purpose, as by this course many years of experiment and much needless expense will be avoided.

Quoting Hardwood again :

But Mr. Burbank does not recommend any difficult problems for the amateur; rather, he insists on the very simplest ones to begin with. He places confidence, the confidence which comes from having accomplished something, as the initial essential * * *.

And to this end he urges taking up a single flower to begin with, never a composite one.

When a certain flower * * * has been decided on, the pollen from one of the two that are going to be crossed in order to give birth to a third that, it is hoped, shall be better than either parent, is gathered upon a little saucer or a watch-crystal, taken to the flower which has been chosen as mate, and dusted down upon its stigma. Then this little flower should be isolated from its fellows and guarded carefully. A paper tag should be fastened to it for identification. Mr. Burbank says to watch the bees, and when they are first a-wing upon their day's work, be sure the flowers are ready to be pollinated.

He says it is wholly unnecessary in ordinary plant breeding to attempt to cover the flower with a screen of tissue paper or gauze. This method has been followed by some in the belief that they were thereby preventing insects from coming in and destroying the pollinating, but he holds that, save in some particular cases, the act is not only absurd but absolutely harmful and more than likely to injure the flower by keeping light and air away from it as to frustrate the very end aimed at. If the pollinating has been thorough, nature may safely be left to do the rest.

Great care also should be exercised in saving the seeds of the plants under test. He recommends air-tight glass jars for the purpose. The jars should be kept in some secure place—it is beyond the power of any mind to say how precious these seeds may prove to be.

From the plants that grow from the new seeds only one should be chosen, the very best of all, the one which is the thriftiest, the best bearing, the nearest to the ideal. The seeds from this one plant should be in turn planted, and then from a very few of the very best plants enough plants saved out to insure a somewhat larger crop for the next generation. Then

from this larger generation only the very best one should be saved. Mr. Burbank lays special stress upon this—to save only one and that the very best of all; no matter if there be hundred plants or a thousand, save only the very best * * *.

According to Hardwood, Burbank's success in being able to judge his plant accurately and pick out the best individual from hundreds and thousands depends on his intuition.

For an amateur, Burbank suggests an outfit consisting of a pair of jeweller's forceps or pincers, a jeweller's eyeglass, a small but powerful microscope, a sharp knife, a saucer for holding the pollen, a soft brush for sifting or dusting the pollen from the saucer to the stigma of the plant to be fertilized. It appears that Burbank himself makes use of any or all of these, sometimes those devised by himself, but chiefly he performs hybridization by securing the pollen upon a watch-crystal and placing it upon the stigma with his finger-tips.

(3) HYBRIDIZATION COMBINED WITH SELECTION.

After a hybrid population is obtained, the next step in improvement consists in the isolation or selection of the best hybrid individual. A hybrid population may often consist of different genotypes and phenotypes. The selection of the best strains may be made either by natural selection or by artificial selection.

In artificial selection results may more quickly be obtained by using line selection. The test of the progeny of each hybrid parent will show at once which parent produces segregation. If the selection be for homozygous individual with respect to a certain character, any test row showing heterozygosity may be eliminated immediately. From the rows which are saved, a number of plants are to be selfed and guarded to prevent crossing with the other plants. Repeated line tests will ultimately reveal the line desired. In vegetatively propagated crops, if a desirable hybrid plant is once obtained, "fixation" of desirable characters is accomplished immediately as it is only necessary to propagate the plant by cuttings, buds or other vegetative parts. Segregation is, at once, prevented this way.

The selection of desirable lines in a population may be left to nature. An example of this practice is found in the work of the

Svalof Station. In Newman's (1912) book, we read: "Still another course of procedure in crossing work, especially with autumn wheat, has begun to be practised at Svalof, viz., *the creating of populations*. Two known sorts are crossed and the whole progeny from all second and succeeding generations is sown together *en masse*. The object of this plan is to allow the severe conditions of winter and early spring to either destroy or expose the weakness of as many of the more delicate combinations as possible. In the latter case the breeder is given an opportunity of assisting nature in her work of elimination by practising a form of mass selection. While there is thus effected in a very simple manner, a gradual weeding out of a great mass of unfit combinations, the progeny of a crossing at the time gradually assumes the character of an ordinary mixed population, the different combinations becoming automatically constant as time passes."

What may be hybridized. This is a question that always assails the curiosity of would-be plant breeders. The tendency of amateur hybridists is to attempt crossing widely related forms. Will mango cross with the lanzon and what kind of a looking fruit will be obtained from the work is the type of question quite often asked. Compatibility between two individual plants is indicated, it would seem, by their systematic position. Crosses between families are unknown. Between genera there are only a few cases. We have the teosinte-maize cross. Several foreign cases of this are known. We have a case of a natural cross between these two plants in the College of Agriculture. In 1918 one-half of a trial plot in this College was planted to teosinte and the other half to maize, *Zea Mays indurata* Stur. The corn variety was Blanco Quarentano introduced into the College through Doctor Weston, of the United States Department of Agriculture. Seeds were harvested from the maize culture and planted. Out of 43 plants produced, 40 were somewhat intermediate in appearance between corn and teosinte. The other three plants looked like normal corn plants, except that they did not produce any ear. Likewise from teosinte seeds, hybrids were produced. Teosinte's specific name is *Euchlœna mexicana* Schrad. Collins and Kempton (1920)

reported that in Mexico both teosinte and maize frequently show contamination. They also reported an artificial cross which they made between Florida teosinte and the Tom Thumb pop corn. Another example of inter-generic cross is a hybrid between radish (*Raphanus sativus* L.) and cabbage (*Brassica oleracea* L.). Gravatt (1914) who reported the case declared that the radish was characterized by a great amount of vigour which was evident from the illustration. However, the hybrid was absolutely sterile.

In species hybrids, a very much greater number of cases are found than in inter-generic crosses. Collins (1917) crossed *Zea ramosa* and *Zea tunicata* and found that these species behave in a Mendelian fashion.

In 1908, Wester (1915) crossed sugar apple (*Annona squamosa*) and cherimoya (*Annona cherimolia*). It is said that the hybrid plants "greatly surpass the parents in vigour, and are very similar in habit, stems, leaves, and flowers to the cherimoya."

Babcock and Clausen (1918) cite crosses between *Antirrhinum molle* and *A. majus*; *Nicotiana alata* and *N. langsdorffii*; *N. alata* and *N. sanderae*; *N. langsdorffii* and *N. sanderae*; *N. rustica* and *N. paniculata*; *N. paniculata* and *N. langsdorffii*; *N. suaveolens* and *N. macrophylla*; *N. sylvestris* and *N. tabacum*; *Digitalis purpurea* and *D. lutea* and between *Oenothera biennis* and *O. muricata*. It is declared that while many of the first generation hybrids in species crosses are more vigorous than either parent, others are exceedingly weak.

Commercialization of improved seeds.

The method of introduction of an improved sort of seeds into general agriculture is something that demands serious study and consideration on the part of plant-breeding students. The value of improved seeds lasts as long as their purity is maintained. Once this is impaired, once contamination by inferior material takes place, a gradual "running out" or diminution of its value may be expected.

Experience in the United States has shown that ordinary farmers cannot very well be relied upon to multiply and guard

selected seeds from contamination or other unfavourable effects. Hence, the Government does most of the multiplication work. When the United States Department of Agriculture has a newly introduced variety for trial, it is generally sent to different state experiment stations or agricultural colleges where it is tested and, if found desirable, multiplied, or sub-tested if necessary, in different counties and introduced into general farming. When farmers have to do the multiplication work, it appears that it is necessary to establish a system of supervision and inspection under which technical men can see that the work is done properly. Where the farmers have had training in technical agriculture, such as those who are graduates of agricultural colleges or who have taken short courses in these institutions, the supervision system is not always necessary.

Probably an ideal agency for the commercialization of improved seeds consists in a seed growers' association which may be placed in charge of the commercialization of the improved seeds that the Government isolates. In this association the members are either plant breeders themselves, or those who understand the principles of technical breeding. Each member has a plot in which he grows his seeds. He himself sees that impurities do not enter into the material from planting to the time it is sold. The association certifies to the purity of the seeds when these are sent to the market. This method is similar to that followed successfully in Canada by the Canadian Seed Growers' Associations and in Europe by the Swedish Seed Associations. These associations are subsidized by their respective governments.

The Tropics have not yet reached the stage when seed growing is a common business and when the seed growers are particular about their seeds. Undoubtedly, the time will come when as a result of agricultural evolution, the method found so successful in Europe and the United States will be adopted in the Tropics.

Meanwhile, improved seeds are generally distributed in small amounts direct to the common farmers who are left to multiply them, the Government purchasing the greater part of the harvest for another and wider distribution. In the Philippines especially,

this has to be done in response to insistent public demand for proofs of what the Government accomplishes in the way of agricultural improvement. Such a procedure is unscientific and wasteful; for the seeds soon become impure before they could benefit a greater number of growers. The Government, perforce, allows the people to profit from the results of technical work rather prematurely. It is believed that, in the long run, better results would be obtained and economy effected, if the seed institutions of the Government were made to handle improved seeds until sufficient amount was available for a very much greater and more general distribution. This should be done until the work is taken up by some seed association that can handle it properly.

The following account by the Howards (1912) of a system of seed distribution to cultivators in India is of interest :

Among the successful schemes of seed distribution in Madras the replacement of the mixed crop by a pure Karungani cotton in the Tinnevely District is a notable achievement. This variety, originally found in a pure cotton tract, was tested on the Koilpatti Farm and proved to be a great advance on the local mixture. A system of seed distribution was then gradually built up, and, at the present time, after five years' work, there are 80,000 acres of this cotton in the district. The agricultural farm grows sufficient cotton to supply the contract seed growers and buys the unginned seed from these men, gins it and arranges the distribution of the seed to the village depôts before the sowing season. Each depôt supplies two or three villages and a suitable man is selected as the depôt keeper who retails the seed under departmental supervision at a fixed rate and on a commission of annas four per bag. The village is regarded as the unit and every effort is made to get all the growers in each village to take up the seed. It is important to notice that the procedure follows that of the best seed growers in Europe and that the seed grown by the contractors is under strict control and comes back to the department every year.

In the Central Provinces, equally striking examples are furnished by the Agricultural Department. In the cotton tracts the work of seed distribution is confined to two suitable kinds, and a fairly large supply of seed is produced on the Government farms which is distributed to private seed growers who themselves retail their seed to the cultivators. In the wheat-growing tracts of this province, the efforts of the department are concerned with distributing pure soft white wheat to selected *malgazars* who are members of the District Agricultural Associations. Each man agrees to sow a large area and to provide suitable arrangements for storing the seed and threshing the crop. In this way it is expected that beginning from a central farm a gradually increasing area of the wheat tract will be sown with one wheat only to the great advantage of the growers and the trade.

The main features of the above examples are that seed distribution starts from a central farm and gradually spreads outwards. The assistance of the best farmers is enlisted, the seed is fully charged for and the work is conducted in tracts where markets already exist for the produce.

NEPS IN COTTON FABRICS AND THEIR RESISTANCE TO DYEING AND PRINTING.*

BY

GLADYS G. CLEGG, M.Sc.,

AND

SYDNEY CROSS HARLAND, D.Sc., F.L.S., F.E.S.,
Of the British Cotton Industry Research Association.

INTRODUCTION.

THE occasional occurrence in cotton fabrics of hairs which resist dye and remain white has been known for some time. As early as 1848, attention was called to it by M. Daniel Koechlin-Schonch¹ of Mulhouse, and he suggested that unripe cotton was responsible for the defect. The question was investigated by Crum,² and at a more recent period Haller³ and Herzog⁴ have made contributions to our knowledge of the subject.

Crum found the undyed portions of the cloth to consist of hairs with remarkably thin and transparent blades, readily distinguishable from ordinary cotton by their perfect flatness and by their uniformly great transparency. The ribbon width was seen to be greater than that of normal hairs and to show numerous longitudinal and transverse folds. Searching among the notes rejected by the "picking machine," he found what appeared to be the same type of hair, in the form of small matted tufts of silky lustre, several of which enclosed the fragment of a seed or, occasionally, an imperfect seed. Crum noticed that small tufts did sometimes pass

* Reprinted from *Jour. Tec. Inst.*, XIV, No. 5.

¹ Crookes. *A Practical Handbook of Dyeing and Calico-Printing*, 1874.

² Crum. *Proc. Phil. Soc., Glasgow*, 1843, **1**, 98; 1849, **3**, 61; *Jour. Chem. Soc.*, 1863, **16**, 1, 434.

³ Haller. *Chem. Zeit.*, 1908, **32**, 838-839.

⁴ Herzog. *Chem. Zeit.*, 1914, **38**, 1089-1097.

the sifting process of the "picking" machine, ultimately appearing in the cloth as minute lumps or knots, and showing white in the dyed fabric. An examination of specimen of dried bolls enabled Crum to trace the real nature of the thin-walled hairs and to make the following observations:—

1. The contents of capsules unopened and slightly opened consisted of thin-walled hairs* or, as Crum called them, dead cotton fibres.

2. In more fully-developed capsules, the ordinary cotton appeared where it had pushed its way out. Seeds nearer the calyx in the same loculus were clothed with the solid mass, chiefly consisting of the glassy, though transparent, hairs.

3. The glassy hairs frequently appeared in pods of ripe cotton in discoloured spots, manifesting signs of injury before maturity.

4. Small portions of dead cotton were seen, though rarely, in the outer part of the wall of well-clothed and ripe cotton seeds.

5. Small glazed tufts in cotton bales, appearing to have separated from the stem through which they derived nourishment, were of frequent occurrence.

Crum pointed out that a distinct gradation is perceptible under the microscope in different specimens, ranging from dead to normal. He stated that the glassy hairs correspond with the cellular membrane, which was described by the earlier botanists as a primary formation in young plants, possessing a considerable degree of toughness and a certain amount of elasticity, having no perceptible orifices, and yet readily permeable by water.

The dead cotton was observed principally in styles employing indigo, chrome-orange, aniline-violet fixed with tannin, or aluminium and iron mordants, where the dyes were attached to the cloth by deposition from basic solutions of their salts. By this method of fixing, with iron and alumina, white spots appeared which, so Crum believed, would not have been discernible if ordinary mordants had been employed. On examining fabric dyed with a safflower-pink, however, Crum observed that the dead cotton seemed to have

* From the botanical point of view the term "cotton hair" is preferable to "cotton fibre."

attracted its full proportion of dye and the same was the case with Prussian-blue produced from stannate of iron. By repeated dips in the indigo vat, the dead cotton was concealed if not otherwise dyed.

Haller agrees with Crum that the occasional hairs which do not take the dyestuff are really unripe cotton, as the following summary of his observations indicates. Under the microscope, the lumen of this type of hair is seen to contain a considerable quantity of matter, and the hairs do not appear to be convoluted so much. When treated with "cuprammonium" the hairs swell up, but do not go into solution. On treating a mixture of ripe and unripe hairs with a solution of iodine in zinc chloride, the unripe hairs quickly develop a blue colour which appears much more slowly with the ripe hairs. A solution of iodine in potassium iodide colours the ripe hairs a dark brown, unripe hairs acquiring only a light yellow colour. In 18 per cent. sodium hydroxide solution, the unripe hairs retain their convolutions, and only become lighter and more transparent. On dyeing with direct dyes the unripe hairs acquire the deeper colour. Treated with tannin-antimony mordant and dyed with basic dyestuffs, unripe hairs are only dyed in the interior, whilst ripe hairs dye homogeneously.

Herzog states that the dead hairs, which are encountered especially in cotton yarns of poor quality, acquire a considerably lower depth of colour on dyeing in the fabric than fully ripe hairs. This he considers to be an optical effect which is connected with the striking difference in dispersion of the two types of hairs. The thickness of the wall of dead hairs is only 0.5μ , and if a section of this order of thickness is cut from a thick-walled, fully ripe hair, no deeper colour is apparent, showing that the depth of the colour is conditioned by the thickness of the wall. If several thin pale blue glass plates are piled together to the height of 1 cm., they will appear less deeply coloured than a single plate 1 cm. thick made of the same glass.

Herzog attempts to distinguish between dead and unripe hairs by their behaviour in cuprammonium solutions, and by their appearance under polarised light. He states that unripe hairs

have a rich protoplasmic residue in the lumen which enables them to absorb substantive dyestuffs more readily than normal hairs. Dead hairs are considered to possess no appreciable cell contents.

EXAMINATION OF FAULTS SUBMITTED.

Certain goods from the Calico Printers' Federation, dyed alizarin style, exhibited defects consisting in the appearance of lighter motes showing up on the dyed background, and in a streaky effect due to irregular variations in the shade of the dyed background. The opinion of the calico printers who submitted the goods was that the white motes are due to "neps," i.e., clusters of short folded immature hairs which failed to absorb either the dye or the mordant or both. They believed that the streaky effect is due to some inferior quality in the cloth receiving its maximum expression in the motes, and stated that the fault is most prevalent in goods dyed with alizarins, para-red and indigo.

The results of examination of the fault will be dealt with under the following headings—(a) The motes, (b) the streaks, and (c) the grey cloth.

The motes. The defects due to motes are of the following main types :—

1. A nep which is only loosely incorporated in the yarn becomes detached after printing, leaving a white area below.
2. A loose end of yarn becomes detached or moved to one side after printing and exposes a white patch below.
3. Small white specks involving a large number of hairs, all of which proved to be dyed normally at other portions of their length. The specks of this type are confined to a single strand of yarn, thus eliminating roller damage as a factor in its causation. More than one type could be distinguished. In some cases the white spot was so far below the general level of the fabric that it could not have been affected by the printing roller. In other cases the mote occurred at the general level of the fabric, and was possibly

protected from the action of the dye by a particle of foreign matter.

4. Neps *in situ* causing lighter spots are by far the most common type of defect. Under a low-power binocular microscope they were seen to consist of a matted tangle of hairs, a few of which showed the rich development of colour characteristic of normal hairs. When dissected, the nep was resolved into a mass of lightly-dyed or undyed thin-walled hairs which, in the aggregate, however, was intensely coloured. The individual hairs were separated from each other with difficulty, and sometimes crumbled to fine particles at the slightest touch of the needle.

When a whole nep was mounted in Canada-balsam, a substance of refractive index similar to cotton, the general shade of colour was not materially different from that exhibited by normal parts of the fabric. This suggested that much of the apparent difference in colour in hand specimens is purely optical, and due, as Herzog suggested, to dispersion effects. It is worthy of note that the surface neps exhibit a high degree of glaze, imparted, no doubt, by the calendering process, and thus reflect more light than the ordinary dyed yarn. Experimental dyeing of the grey cloth with Congo-red failed to reveal any marked differences in shade, but on treatment with a hot iron in a damp condition to imitate the calendering process the neps became glazed and immediately showed up as typical light patches. In fabrics dyed with para-red, however, the moles were prominent in uncalendered goods, and the intensifying effect of calendering is, therefore, not universal.

The streaks. A defect in dyeing is often shown in the presence of light streaks confined to a single strand of yarn, extending in some cases to a length of 6 mm. or more. When the cloth is held up to the light the streaks are dark, rather than light, and this is also the case in specimens cleared in clove oil and mounted in balsam. Under the microscope, the same matted tangle of thin-walled, fragile hairs was seen, with a few strongly dyed normal hairs running ridge-like across the semi-glazed surface. The streaks may thus be regarded

as elongated neps. When dissected, the tangled mass resolved itself into a mixture of unthickened and partially thickened hairs, together with broken tips of hairs. On the whole, the elongated neps were essentially the same in structure as the surface neps previously described.

A point of some importance, however, requires emphasis. Although most of the hairs in neps were undoubtedly weakly dyed, there were isolated patches of the debris in which colour could not be seen. In spite of the difficulty of manipulation, small portions of such hairs were treated with sodium hydroxide of the usual mercerizing concentration, and measurements were made which showed that no shrinkage had taken place; it is therefore clear that associated with the tangle of thin-walled hairs was a matrix of hair debris with practically no secondary thickening. This debris exhibits dispersion effects to a high degree, particularly when glazed, but, on account of the absence of dye, becomes almost invisible in mounting media of approximately the same refractive index.

A comparatively uncommon type of streak consisted of a group of hairs which were not so thin-walled as to form neps in the spinning process, but which were too thin-walled to exhibit the full development of colour. There was only a slight difference in colour from the rest of the background.

The grey cloth. A sample of the grey cloth before dyeing was examined, with the following results:—

1. Tufts of thin-walled hairs, exhibiting parallelism, could be readily recognized by their semi-glassy appearance. Dyeing of these portions would result in a localized slight diminution of the full shade of colour.
2. Neps consisting of thin-walled hairs in a matted and tangled condition were abundant. Most of these were yellow in colour.
3. Seed coat particles were abundant, and often formed the nucleus of neps.

Tufts of thin-walled hairs, similar to those described under (1) above, are a common feature of normal seeds, and are to be

ascribed to unfavourable conditions of nutrition during growth, a question which will receive fuller discussion later.

Yellowness of thin-walled hairs is invariably a consequence of attack by insect or cryptogamic parasites during boll development.

A large amount of thin-walled, yellow-stained cotton occurs in West Indian, Sea Island cotton through this cause, and is baled and shipped specially as stained cotton.

EFFECT OF MERCERIZATION ON THE COLOUR OF THE NEPS.

An indigo-dyed fabric in which the neps were of conspicuously lighter shade than the background was compared with similarly dyed cloth which had previously been mercerized. The general result of mercerizing was to render the defect much less obvious. This fact is apparently well-known to the trade, and has its explanation in the change of geometrical conformation of a mercerized hair. The flattened ribbon, characteristic of a thin-walled hair possessing an appreciable amount of secondary thickening, is converted on mercerizing into a form in which the area of cross section tends to be circular and in which dispersion effects are minimized. The wall thickness is considerably increased and a greater capacity for taking the dye results. The primary wall debris containing no cellulose is not affected by mercerizing and thus the defect is still visible to some extent.

SUMMARY OF OBSERVATIONS AND CONCLUSIONS ON THE FAULT.

1. The presence of motes and streaks of a lighter shade than the dyed background is mostly due to the presence of neps.
2. The neps consist of a matted tangle of thin-walled hairs which, in surface view, exhibit a glazed appearance.
3. The thin-walled hairs are essentially of the type described by Crum as "dead cotton."
4. Herzog's view that the difference in shade is purely an optical effect is substantiated on two main grounds: (a) Elimination of dispersion effects by immersion in various mounting media

renders the difference in shade in dyed hairs practically negligible ; and (b) in experimentally dyed cloth, the moles and streaks only appeared when the glazed surface of the neps was produced with a hot iron.

THE CELL-WALL THICKNESS OF COTTON HAIRS.

Since the main cause of the differences in shade of the dyed background of the fabric has been established to be due to thin-walled hairs, i.e., to unequal distribution of wall thickness in the hairs composing the yarn, it is advisable to discuss the question of wall thickness in some detail, more particularly with reference to the causes of variations in magnitude and mode of distribution of this character.

Balls¹ points out that if, for any reason, the cell-wall of the hair consists mainly or entirely of primary wall with little or no secondary thickening, there will be little resistance to bending stresses. Consequently, such flabby hairs will be easily rolled into a tangled nep or coil. Such hairs are more likely to occur in fine cottons which have normally a thin secondary wall. Some environments produce more than others, as also do some varieties ; thus West Indian, Sea Island cottons are bad in this respect, whilst Sakellaridis Egyptian cotton is inferior to the varieties which it has replaced, and the now extinct Yamovitch cotton was remarkably free from nep. Since one of the causes of flabby hairs is genetic, it is clear that the recognition and elimination of strains possessing an abnormal amount is one of the most promising methods of reducing nep.

PRODUCTION OF NEPS DURING MANUFACTURE.

Given the presence of hairs with thin walls, there are many opportunities during manufacture which are likely to produce neps by their differential reaction to bending stresses. Among the recognized causes of neps are the following :—

In ginning.—Faulty ginning.

In scutching.—(a) Excessive beating ; (b) beater blades out of order ; (c) trying to get too much cotton through one machine.

¹ Balls. *Handbook of Spinning Tests for Cotton Growers*, London, 1920.

In carding.—(a) Carding too heavily; (b) neglecting stripping and grinding; (c) bad setting of flats, rollers and clearers, doffer and doffer combs; (d) allowing the web to become broken and to fill up all space between the doffer and the calender roller, until the cotton is carried over the doffer and fills up the doffer comb, so that a portion of the hairs remains subject to the action of the comb for some time; (e) overloading the wire.

THE BOTANICAL ASPECT.

From the point of view of the botanist, there are two sets of factors influencing the cell-wall thickness of cotton hairs; these are respectively environmental and genetic.

The influence of the environment on cell-wall thickness. In the first place, it is beyond dispute that each individual cotton plant possesses a certain association of genetic or hereditary factors which, under constant environmental conditions, are capable of manifesting themselves in the production of hairs of a definite length and wall thickness. Environmental conditions, however, can never be equal in their effect on all parts of the plant. For purposes of discussion, they may be divided into two main classes, external and internal.

The external environment includes within its scope soil conditions, water supply, temperature, humidity, density of population, air movements, illumination, etc. A change in the general environmental complex will, in some way, be reflected in mean cell-wall thickness, and in support of this statement may be adduced the well-known seasonal variations in the quality of the cotton crop from year to year, grown from the same seed. Thus, when seed of Superfine St. Vincent cotton was grown in a region of little rainfall the wall thickness apparently increased *pari passu* with the environmental aridity, but when grown in the humid greenhouse of the Shirley Institute, the wall thickness was reduced so that the cotton was virtually of the same magnitude as that characterizing "dead cotton."

The internal environmental effect is chiefly positional. There is competition for nutrients from boll to boll, from seed to seed in the

boll, and from hair to hair upon the seed. In examining cross sections of hair from the same seed, it is not unusual to find patches of one to two hundred hairs closely grouped together, characterized by thin cell-walls. It is clear that proximity to the nutritive channels plays an important part in the determination of wall thickness. Patches such as this not infrequently pass through to the finished yarn, as was noted in the discussion on the fault described in this paper. The differences in the position of bolls on the plant would make itself felt as an influence upon wall thickness even if they were all at the same stage of maturity at the same time. This is not so, however, and in practice the later bolls on the plant usually mature at a time when, by reason of senescence or attack by cryptogamic parasites, the leaf area of the plant capable of photosynthetic activity has been considerably reduced. Not to be forgotten, also, is the effect of reproduction in photosynthetic activity due to defoliation by leaf-eating caterpillars, which in some cotton-growing districts may take place at almost any period of the growing season. It will be seen that distribution of wall thickness of hairs in a given bale is necessarily patchy. Uniform environment on the seed coat does not involve more than a limited area, and elimination of positional effect can only take place in hairs which are adjacent on the same seed.

The influence of competition from seed to seed in the same boll may, in extreme cases, result in the death of half-grown seeds, which are clothed with hairs of little or no secondary thickening. Examination of a large number of bolls both of Upland and Sea Island cottons shows this phenomenon to be of frequent occurrence, so much so that probably most of the flabby hairs in undiseased cotton is due to this cause.

The influence of genetic factors on cell-wall thickness. It is probable that the death of some of the partially developed seeds in the boll is due to gametic incompatibility, i.e., the combination of male and female elements which have united to form that particular seed is non-viable after a certain age. Some varieties differ constantly in the percentage of non-viable seed, and the basis of this can only be genetic.

Death of seed through attack by insect or cryptogamic parasites.

It has been mentioned above that the death of seeds either through competition or for genetic reasons is a fruitful source of flabby hairs. Death of seeds may also be caused by boll-puncturing insects, chiefly types of plant bug, carrying various forms of fungoid infection. In this case, the seed may be drawn upon by the insect for its food supply and ultimately killed, or a general growth of micro-organisms may additionally supervene and involve the whole boll in decomposition and disorganization. Certain boll diseases may attack the external wall of the boll, and, by progressive penetration, destroy more or less of the boll contents.

Whatever the cause of the death of a seed in a half-matured condition, the hairs on that seed are invariably excessively thin-walled and weak, and are likely to initiate neps in the spinning process. The yellow colour, whether due to insect puncture or disease, is strongly characteristic, and such cotton may be suspected as the source of some at least of the neps in neppy cloth.

GENERAL CONSIDERATIONS.

It is clear from what has been said above that the existence of thin-walled or flabby hairs in a sample of cotton is due to a variety of causes, some of which are partially avoidable and others inevitable. The consumer of cotton is at present helpless in the hands of the agriculturalist. His most urgent requirement is uniform cotton, and in regard to the present problem of thin-walled cotton, the position may be summed up by saying that the variability of the wall thickness should be reduced to a minimum. Those engaged in cotton breeding are urged to take up the study of means of eliminating strains characterized by thin-walled cotton, and to investigate the physiological and genetic factors conditioning its appearance. From the point of view of the spinner, the recognition of raw cotton containing abnormal amounts of thin-walled hairs is important, and a method is under consideration whereby it is hoped to establish definite standards for wall thickness in varying types of cotton, and in conjunction with this to obtain an idea of the number of thin-walled hairs normally present.

SUMMARY.

1. The work of Crum, Haller, and Herzog is summarized.
2. The results of microscopic examination of an alizarin-dyed fabric which showed motes and streaks are presented. The conclusion is drawn that the defect is one essentially similar to that described by Crum, and is attributable to neps composed of thin-walled hairs. The difference in colour of the neps is considered to be mostly optical in nature, for reasons which are given, but the nep aggregate apparently contains debris of hairs consisting of primary wall only, which are glassy in appearance and remain undyed.
3. The effect of mercerization on the difference in colour shown by neps in an indigo-dyed fabric is to render such difference less conspicuous. This is considered to be due to alteration in the shape of the cross section, reducing dispersion effects, and to an increase in the wall thickness, which causes an increased capacity for dye.
4. The cell-wall thickness of cotton hairs is considered in detail and reference is made to recognized causes of neps during manufacture.
5. The effect of environmental and genetic factors on cell-wall thickness is shown to be complex, and it is concluded that much of the thin-walled cotton arises through death of seeds before maturity, either through competition, genetic factors, or attack by parasites.
6. Elimination by genetic methods of strains characterized by excessive amounts of thin-walled cotton is suggested to the cotton breeder, as well as a detailed study of the physiological and genetic factors influencing its amount.

Notes

OIL CONTENT OF CASTOR SEEDS AS AFFECTED BY CLIMATE AND OTHER CONDITIONS.

EXPERIMENTS with castor seeds were first initiated at Sabour by Mr. C. Somers Taylor, Agricultural Chemist to the Government of Bihar and Orissa. In the first series, the results of which have already been published by him (*Pusa Bull.* 117, 1921), attempts were made to determine whether by chemical selection it was possible to improve the race of castor as regards its oil-yielding properties. It was, however, found that although seeds collected at random gave widely varying oil-content— from as low as 21·8 per cent. to as high as 50·8 per cent. on the seed—this character was not transmitted, when grown under similar conditions, even for one generation; their progeny giving almost in every case a mean oil-content of about 49 per cent. in healthy seeds. The *bhadoi* (monsoon) crop, which was generally well developed that year, gave a better oil-yield than the same variety grown as *rabi* (winter) crop. It was then thought possible that weather and other conditions might exert some influence on the oil-yielding properties. Selected seeds, having an oil-content of 50 per cent. or above, were distributed for growth to the different farms where different conditions might prevail. Samples of the crop grown from these seeds were obtained from Cuttack, Dumraon, Sambalpur and Sepaya, but with the exception of the last of which the *bhadoi* crop gave a lower oil-content (43·3 per cent.), all others maintained their oil-yield. Many of the kernels of the samples of the *bhadoi* castor grown at Sepaya were found to be in a shrunken condition indicative of unhealthy growth. Again the Pachka castor grown on the Sabour farm, both as *bhadoi* and *rabi* crop, gave the same oil-content in each case (51·0 and 51·6 per cent. on the whole seed). The climate therefore does not seem to exert any appreciable

influence on the oil-yielding properties of the crop, except so far as it affects proper development of the seeds.

Different manurial treatments also do not seem to have any effect on the oil-content of the seeds. Lines were laid down at Sabour to receive separately potassium sulphate, superphosphate, and ammonium sulphate, as well as a mixture of these three and cowdung and *basti* ash, i.e., ash of the village refuse. The seeds used were from the same parent. The application of the manures resulted in a considerable increase in the yield of seeds but the percentage of oil in the seeds remained singularly constant. The following table will make this clear:—

	Control	Pot. sulph.	Super.	Ammon sulph.	Mixture	<i>Basti</i> ash	Cowdung
Yield of seed in lb. wt. . .	6.44	13.19	11.06	12.50	13.19	10.41	14.16
Percentage of oil in seeds . .	51.35	52.05	51.50	51.75	51.27	51.80	51.70

Attempts were also made to find if the amount of space left between the plants had anything to do with better development of seeds and consequent higher production of oil. Bulk seeds originally from a single plant, were sown, allowing different spaces between the plants and also from line to line, but no considerable effect was perceptible in respect either of the total yield or of the oil-content of the seeds. On the other hand, the wider space allowed the plants to produce more branches, each of which produced heads which took its own time to mature and consequently they could not be harvested all at the same time. Plants in which 2 feet spacing was allowed from line to line and 1 foot 6 inches to 2 feet from plant to plant produced only one long head and were therefore more convenient to harvest.

It was found that the seeds on the oldest head of a plant gave an average result of 50.7 per cent. oil, while those on the youngest and therefore less mature head from the same plant gave 47.8 per cent. oil. The amount of oil present in individual seeds seems to depend therefore not directly on climate or on manurial treatment, but on the degree of maturity of the seed.

The method of harvesting adopted by the cultivator in Bihar is to remove the head, of which only a few of the top seeds have ripened, the rest of the seeds attaining maturity slowly after keeping. A trial was made to find out whether this method would give seeds of the same oil-content as those obtained by removing matured capsules only. Several plots were laid out, each plot being sown with seeds which originally came from the same parent plant. The result is indicated in the following table:—

Percentage of oil on the whole seed.

Plot No.	Removing matured capsules only	Harvesting in cultivators' method	Difference in favour of the former method of harvest
2	52.9	52.7	0.2
3	53.4	51.0	2.4
5	48.3	48.3	nil
6	49.9	49.7	0.2
11	51.1	51.3	—0.2
12	48.6	49.0	—0.4
7	50.2	47.2	3.0
8	49.7	46.0	3.7
14	49.5	49.8	—0.3
16	51.0	48.6	2.4
17	47.3	47.3	nil

Thus, against three cases out of eleven where there was a very slight difference in favour of harvesting whole heads, there are four where the removal of matured capsules gave a considerably larger percentage of oil. Although after the removal of the whole heads, the seeds were kept apart for several weeks in order to allow them to ripen, the degree of maturity was not the same in all cases, and even the slight difference in maturity in different seeds from the same head seemed to have a considerable effect. This therefore strengthens the conclusion that the oil-content of castor seeds

depends more upon the degree of maturity than on anything else. The Bihar cultivators' method of harvesting does not ensure that the seeds will have their maximum oil-content and cases may arise in which the average oil-content may fall short by over $3\frac{1}{2}$ per cent. of what can be obtained by harvesting them when all are fully ripe.

It is clear that for purposes of analysis with a view to the selection of superior oil-yielding types, great care should be taken to pick individual capsules as they mature. [MANMATHA NATH GHOSH.]

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BUD-ROT OF COCONUTS CAUSED BY *PHYTOPHTHORA* *PALMIVORA*.

DURING 1913-14 inoculation experiments were conducted on young coconut palms with the fungus *Phytophthora palmivora* by Dr. Shaw and myself (*Annales Mycologici*, XII, No. 3, 1914). It was then proved by a number of inoculations that this fungus produces typical bud-rot on young coconut seedlings. Later on it was doubted by Mr. Sharples in one of the papers in the *Annals of Botany* (XXXVI, January 1922, p. 55) whether in mature coconut palms this fungus can cause typical bud-rot. I felt sure from my close knowledge of the parasitic nature of this fungus that it can produce the bud-rot in mature trees as well as in the seedlings.

With a view to confirm my statements, two well-grown healthy trees about 15 years old and with stem measuring about 12 feet in height were selected for the experiment. Diseased specimens of leaves and leaf-sheaths from a bud-rotted coconut tree in Kasargode, South Kanara, were obtained on 15th August, 1922. Fresh masses of mycelium and sporangia were found inside the folds of the diseased leaves. From this material a pure culture was obtained on French bean and oat agar on 18th August, 1922, and subcultures were made from these from time to time.

On 29th November, the two coconut trees selected for the experiment were inoculated with subcultures of 18th September. The fungus material was removed from the culture tube carefully

with a sterile platinum scoop and mixed with a few drops of sterile water. This material was carefully placed inside the shoot of the trees which were wetted with sterile water before inoculation. The outer portion was covered over with a mass of coconut fibre which was kept wet by splashing water over it. Spray of sterile distilled water was given every day to the shoots in which the fungus material was put. Two more trees were treated in this way but without the fungus being put in the central shoot and kept as control. On 11th December, i.e., thirteen days after inoculation, characteristic diseased spots were seen on the leaves where the fungus was put. A week later, the shoots of both the inoculated trees showed signs of yellowing. They were given regular spray of sterile water every day. Ten days after the spot formation was noticed, that is, on 21st December, the shoots rotted and could easily be pulled out from the crown.

Microscopic examination showed the presence of the fungus *Phytophthora palmivora* on the inoculated portions. A bit of the diseased portion was incubated and the same fungus was re-isolated.

At this stage, wetting the crown with the spray of water was discontinued. In the course of two months, the crown of the two trees as a whole were blown over by wind leaving the two trees as bare poles. The controls remained healthy throughout the experiment. This clearly proves that the fungus *Phytophthora palmivora* can produce typical bud-rot on mature trees also. In nature, tall, mature trees are noticed killed by this fungus with the bud completely rotten. [S. SUNDARARAMAN.]

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INDIAN DIPLOMA IN DAIRYING.

THE following press communiqué, dated 13th November, 1923, has been issued by the Government of India (Department of Education, Health and Lands):—

The Government of India have decided, in connection with the working of the Imperial Institute of Animal Husbandry and Dairying at Bangalore, to institute an Indian Diploma in Dairying on the lines of the British National Diploma in Dairying, to be

granted to persons who have successfully completed a course of not less than two years' instruction at an institute recognized by the Imperial Institute as capable of teaching up to the standard required for such a diploma.

It is hoped that sooner or later Agricultural Colleges in India will possess the necessary staff and equipment and will be willing to train pupils for this diploma, but, for the present, the necessary course of instruction will be commenced on January 1st, 1924, at the Imperial Institute of Animal Husbandry and Dairying, Bangalore, where eight selected pupils will be taken.

The course will last for two years with two months' vacation each year. The holiday period will be the months of April and May.

The course will consist of practical and scientific training in the principles of cattle-breeding, cattle feeding and management, Indian and foreign breeds of dairy cattle, stock judging, diseases of dairy cattle, dairy farm buildings, milk production, handling and sale, butter and *ghi* manufacture, dairy chemistry, dairy bacteriology and dairy farm book-keeping. Ample scope is available for practical and laboratory work at Bangalore. The practical instruction will be under the direction of the Imperial Dairy Expert and the scientific training will be carried out under the control of the Physiological Chemist to the Government of India.

Students must be of good character and over 17 years of age. The minimum educational qualification necessary for admission is the Matriculation or the School Final Examination, but, in special cases, the Imperial Dairy Expert will have power to waive this condition.

A tuition fee of Rs. 15 will be charged from each student for each month or part of a month he is actually in residence at the Institute. Accommodation will be provided free of charge which pupils must avail themselves of. No stipends will be paid to students and travelling expenses must be borne by students themselves.

At the close of the course an examination will be held for those students who have satisfactorily completed the course of instruction, and the Indian Diploma in Dairying will be awarded

by the Imperial Institute of Animal Husbandry and Dairying to successful candidates.

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THE SECOND WORLD'S POULTRY CONGRESS AND EXHIBITION.

THE Second World's Poultry Congress will be held in Barcelona from 10th to 16th May, 1924, under the official patronage of the Spanish Government and of the Municipality of Barcelona, and under the Honorary Presidency of H. R. H. The Prince of Asturias, Honorary President of Spanish Aviculturists. The opening sessions and sectional meetings of the Congress will continue up to 14th May in Barcelona and the closing sessions will be held in Madrid on 16th May. The deliberations of the Congress will include such important topics relating to poultry breeding and industry as : (1) Research and investigation. (2) State-aided and voluntary efforts to develop the poultry industry (inclusive of educational work, (3) Hygiene and disease, and (4) National and international trade in eggs and poultry.

The Exhibition, which will be held simultaneously with the Congress, opens on 10th May and will be installed in the Exhibition Palace at Barcelona. It will remain open for nine days, from 9 a.m. to 6 p.m. each day. The Exhibition will be in the nature of a display, the object being educational and not competitive ; and it is intended to represent every branch of poultry industry and commerce therewith.

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CONSUMPTION OF AMMONIUM SULPHATE IN JAVA.

THE American Vice-Consul Rollin R. Winslow, Batavia, in a report published in the Commerce Reports of the United States Department of Commerce, dated 17th September, 1923, states that considerable amounts of chemical fertilizers are used in Java and that these are admitted duty-free.

Ammonium sulphate is the principal fertilizer used, and of the 70,740 tons imported in 1922, 23,646 tons came from the United States and 35,726 tons from Great Britain. The amount from the United States shows a decided increase over the previous year, principally because of the fact that Germany is being forced to

withdraw from the market. Before the war considerable quantities were imported from Germany, but that country has not regained its place. The Germans are still in the market to a slight extent, but the chaotic conditions there have forced buyers to look elsewhere, particularly because deliveries are uncertain.

There is a wide variation in the amounts of ammonium sulphate used by the different estates in the Netherlands East Indies. Some lands recently reclaimed from the jungle do not require any, while the older estates, where the soil is heavy, use up to 10 piculs to the bouw, or about 800 pounds to the acre. It is claimed that no other artificial fertilizer is so well adapted to the cultivation of sugar.

The sugar estates generally place their orders a year in advance. They require that the ammonium sulphate contain an average of about 20 per cent. nitrogen, and approach a fixed standard of moisture content. Further, it should be free from sodium, and not contain more than 1 per cent. of free sulphuric acid. Packing is usually in bags of 112 to 200 pounds.

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SUGARCANE CULTIVATION IN BARBADOS : INCREASED PROFITS FROM NEW SEEDLINGS.

THE Barbados Agricultural Society have requested the Governor to appoint a Commission to enquire into the working of the local Department of Agriculture to make recommendations for properly equipping it to carry on its work in an up-to-date manner.

That this was not intended as a reflection on the conduct of the department was shown by the fact that the resolution authorizing the request was moved by Mr. John R. Bovell, the Director.

In the course of his remarks on this occasion Mr. Bovell made the striking statement that during the eight years 1913-15 to 1920-22 the growers of sugarcane in Barbados benefited by the work of the Department of Agriculture, in round numbers, to the extent of something like ten million dollars and the factory owners by an additional sum of ten million dollars as a result of growing the better seedling sugarcane when compared with the White Transparent.

In support of his contention, Mr. Bovell said that on the average for those eight years the White Transparent yielded 20·45 tons of canes per acre, the B.H.10(12), 29·05 tons, Ba. 6032, 31·76 tons and the Ba. 11569, 26·84 tons of canes per acre per annum respectively. That is, these three canes under the same conditions for the eight years averaged 29·22 tons of canes per acre, while the White Transparent averaged 20·45 tons, an increase of 8·77 tons or 42·9 per cent.

During the eight years the average price at which dark crystal sugar sold was \$4·90 per 100 lb. At this price, and at 7 lb. of dark crystal sugar per 100 lb. of sugarcane, the value of a ton of canes was \$7·68, so that the value of 8·77 tons of canes was \$67·35 per acre per annum more than the White Transparent.

From this would have to be deducted the extra cost of cutting, loading and carting the better canes, say 72c. per acre, leaving a net gain of \$66·63 per annum. It was generally estimated at the present time that about 35,000 acres of canes were reaped annually. Assuming that of this area only 20,000 acres were under the seedling sugarcane mentioned above, although believed that there were more, the value to the growers would at \$66·63 per acre be \$1,332,600 per annum or for the eight years \$10,660,800.

Proceeding, Mr. Bovell, after dealing with the experience of an estate in the dry district, showed how increased expenditure on the department would be justified by results in such lines of work as, for example, increasing the yield of sugarcane per acre by growing them from stools containing the average maximum number of canes per stool and by improving the quantity and quality of cotton produced.

The resolution, which was seconded by Dr. Gooding, was carried unanimously. [*The West India Committee Circular* 653.]

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COIMBATORE CANE SEEDLINGS IN ANTIGUA.

A CORRESPONDENT in Antigua writes:—“The North Indian seedling canes—these are doing wonderfully. All of the varieties have germinated well and although the canes were only planted in

the end of April or early May, they are a long way ahead of many plants six months older. Harcourt, the Assistant Director of Agriculture, has taken no end of trouble with them. He sunshaded and watered them at first till they started to grow. You will indeed be pleased when you see them."

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STUDY OF SUGARCANE ROOT-ROT IN JAVA.

MANY reports having come to the experiment station for the Java sugar industry that root-rot seemed to occur in sugarcane fields planted in succession with the same variety of cane rather than in fields where one variety was followed by a different variety, an exhaustive investigation was undertaken by Dr. J. H. Coen. The investigation showed that while there was some ground for the current opinion, the reason is not that one particular variety poisons the soil for itself more than another variety. What appears to happen is that the infection of the soil persists for some time after the harvest, and the chance of root-rot depends on the length of time elapsing between harvesting and replanting. From the data it appears with tolerable clearness that the chance of root-rot is greater if the cane planted in succession is a later ripening variety and less if it is an earlier ripening one, because in the latter case the land remains unoccupied for a longer time.

For the same reason, a three-year rotation gives less occasion for root-rot than a two-year rotation.

It also appeared from the investigation that root-rot is very rarely met with in the red soils (lateritic) of Java.

Of the 9,493 bouws studied, 443, or 4.67 per cent., were affected by the disease; where the rotation was three-year the percentage was 3.43; where the rotation was two-year it was 10.42. [*Facts About Sugar*, XVII, 10.]

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EUROPEAN BEET CROP, 1923-24.

THE latest estimates of the beet sowings in Europe and production of sugar in season 1923-24, as compared with the actual

acreage and realized production of the season 1922-23, are as follows :—

Names of countries	1923-24		1922-23	
	Hectares	Tons of sugar raw value	Hectares	Tons of sugar raw value
Germany	343,520	1,190,000	363,789	1,163,000
Czecho-Slovakia	219,486	830,000	184,591	726,472
Austria	12,600	40,000	11,563	24,000
Hungary	44,308	110,000	30,020	82,000
Poland	143,000	400,000	110,000	301,800
France	149,848	450,000	127,450	493,000
Holland	73,500	270,000	57,536	255,592
Belgium	72,264	260,000	59,176	268,928
Italy	90,000	310,000	85,321	297,280
Spain	60,000	180,000	48,015	170,000
Denmark	32,000	110,000	23,944	90,000
Sweden	43,700	150,000	16,716	71,800
Russia	230,000	330,000	173,000	200,000
Other countries	69,925	180,000	59,745	108,000
	1,584,151	4,810,000	1,352,886	4,551,962
TOTAL IN ACRES	3,914,437	..	3,342,981	..

The present estimate thus shows an increase in production of about 258,000 tons in 1923-24 as compared with the last year.

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WORK OF THE IMPERIAL INSTITUTE.

We have received the following for publication :—

The Imperial Institute for many years has been steadily endeavouring to further the development of the resources of the Empire, particularly with regard to the commercial and industrial utilization of raw materials of all kinds. The best known department of the Institute is its well-arranged Exhibition Galleries, open to the public and schools, in which are displayed the principal raw products and manufactures of the various parts of the Empire, accompanied by descriptive labels and illustrated by maps, diagrams, photographs and models. This is the only permanent exhibition of the kind in the Empire.

Less familiar to most people is the important work of the Scientific and Technical Department, which investigates the new or little-known raw materials of the Empire, and suggests action for

their commercial utilization. The Technical Information Bureau deals with enquiries of the most diverse origin and character connected with the production, utilization and valuation of raw materials. A vast amount of information emanating from the Institute has been disseminated by means of the Institute's Bulletin and other publications, and also through other channels, including the Chambers of Commerce.

An opportunity of becoming better acquainted with the nature of the Institute's activities and the many important results which have accrued from its work is now afforded in a recent issue of the "Bulletin of the Imperial Institute." This publication is devoted to a comprehensive report on the operations of the Imperial Institute carried out by its different Departments and various Technical Advisory Committees.

Further examples of the important work of the Institute are contained in the current issue (No. 2 of 1923) of the same Bulletin.

A full account is given of the lignite deposits of the Southern Provinces of Nigeria, which were discovered during the Mineral Survey carried out under the auspices of the Institute. The deposits exist over a considerable area, some being favourably situated for transport. A detailed study of the lignite in the laboratories of the Institute showed that it was of satisfactory composition and calorific value. It is quite suitable for briquetting, and briquettes used as fuel in firing trials in railway engines and steamboats in Nigeria have proved satisfactory.

Another article summarizes the investigations conducted at the Institute under the Ceylon Rubber Research Scheme. Particulars are given of the results of tests of a large number of specimens, prepared in Ceylon by different methods, with a view to ascertaining the mode of preparation best suited to the needs of the manufacturer.

Other subjects of interest referred to are Indian worm-seed as a source of the drug *santonin*; a new essential oil obtained from a Western Australian plant; and the results of practical pottery trials with Australian clays. There is also an interesting illustration

article on the trees of the Gold Coast. The value of a number of Gold Coast and other Colonial timbers is being investigated at the Institute with the advice of a Committee which includes representatives of the timber trades and industries of England.

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INCREASING CONSUMPTION OF NON-AMERICAN COTTON IN LANCASHIRE.

THE use of outside growths of cotton in Lancashire and on the Continent is developing largely, and what is more astonishing is the great demand for dirty cotton. In past years Lancashire spinners would not "look at" such cottons as they are eager to obtain now. There has been a great deal of substituting American cotton by Egyptian owing to the relative cheapness of the latter, but manufacturers hesitate to do so on account of the complaints that are bound to arise when the normal state of affairs returns and American yarns are again used, as it is then that the customers complain of a falling-off in quality of the cloth and trouble begins.

The extent to which outside growths of cotton are being used in England is evident from the takings of American cotton from August 1st to March 16th. England took 22,000 bales less than in the previous year for the same period, but the total of all kinds of cotton taken by Lancashire spinners was 1,828,047 bales against 1,672,767 in the previous year- an increase of 155,280 bales. (*International Cotton Bulletin*, No. 3, 1923.)

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COMPULSORY COTTON STANDARDS IN THE U. S. UNDER THE NEW COTTON STANDARDS ACT.*

COTTON classification is of very great importance to the grower in the United States as well as to the spinner. If the uniform standard be obtained applicable to grower, merchant, distributor

* Mr. Charles J. Brand held recently meetings with the various Cotton Exchanges in Europe and called at the offices of the International Cotton Federation. This article is the summary of Mr. Brand's arguments in favour of the universal introduction of the American Cotton standards. [A. S. P.]

and spinner alike, economy and better understanding cannot fail to result.

In August 1914, the United States Cotton Futures Act authorized the establishment of standards by which the quality or value of cotton might be judged quoting its grade length of staple, strength of staple colour, and such other qualities, properties and conditions as it might be practicable to determine standards for. The grade standards established under that law were made compulsory in the United States in all transactions involving future contracts on the grade exchanges. These standards, with one slight change, have now been in use for 9 years. More recently permissive length standards have been established, and are being found useful in the arbitration of disputes.

Spinners realize as fully as any manufacturing interest in the world that in every plant the necessity for economy and efficiency is a fundamental consideration. They have standardized their machinery, their processes, their manufacturing practices, their policies of management, and every other conceivable thing. Standardization of product, whether yarn, cloth or otherwise, plays a large part in the magnificent development of the cotton spinning industry of the past 70 years.

Standardization of the raw materials for manufacture is of quite as great or even greater importance as the standardization in the successive phases of the industry. High-class production can only be attained when the farmer in America knows what the spinner wants. Waste and needless expense in the field of merchandizing, and in the processes of trade are a tax upon the well-being of the whole cotton trade, and can be avoided to a larger extent than is now the case through the adoption and application of universal standards.

Having in mind the benefits that have already attended a general use of uniform standards in the American markets, the Congress of the United States has passed a law that compels all transactions of grade in inter-state and foreign commerce to be in accordance with the grades hereafter to be known as the official Cotton Standards Act of the United States.

A brief discussion of the provisions of this law which was passed on March 2, 1923, will no doubt be of interest to the members of the International Federation of Master Cotton Spinners.

WHAT THE NEW UNITED STATES COTTON STANDARD LAW REQUIRES.

The law compels every cotton merchant, shipper, buyer and trader in the United States in every transaction or shipment in inter-state or foreign commerce, and in every publication of prices, and in quotations of cotton for shipment in inter-state and foreign commerce, and in the classification of all cotton, to use the official cotton standards of the United States, provided the quality of the cotton involved in the transactions is of or within the range of the official cotton standards of the United States.

The law provides within these specific terms that its compulsory features shall not become effective until one year from the date on which the Secretary of Agriculture promulgates standards for the purposes of the law. In other words the logical and likely procedure is that at the close of the present cotton year or during the month of July, the Secretary will announce standards which at the expiration of 12 months of the date of this announcement will become compulsory upon all citizens of the United States.

Thereafter, bills of lading, warehouse certificates, shipping documents, insurance contracts, newspaper and private quotations of cotton by grade, invoices and all other documents will be required to be stated in accordance with official cotton standards.

The Act further provides in Section 2 that nothing therein shall prevent transactions otherwise lawful by actual sample or on the basis of a private type which is used in good faith and not as a means of evasion of or substitution for the official standards.

Any person who has the custody of, or a financial interest in, any cotton, may when the Act comes into full force submit the same or samples thereof, which must be drawn in accordance with

the regulations and safeguards imposed by the Secretary of Agriculture, to such officer or officers as the Secretary may designate for a true determination of the classification. The final certificate of the Department of Agriculture will be binding on all officers of the United States and will be accepted in the courts of the United States as *primâ facie* evidence of the true classification of the cotton itself or of the samples thereof when involved in any transaction or shipment in inter-state or foreign commerce.

The United States Government under the law is authorized to prepare copies of standards and to sell them at a cost to any person who may ask for the same. These copies are to be certified under the grade seal of the department, and the attachment of that seal will include regulations for the inspection, condemnation and exchange of standards in order to make certain that copies in use are accurate and suitable for commercial purposes.

Persons who tamper with, alter or change copies of standards excepting those who have the written authority of the United States Government to do so, or who use the standards with intent to deceive or defraud, or who counterfeit or simulate copies of the standards, are subject to a fine of \$1,000 or imprisonment or both. The same penalties attach to persons who falsify or forge certificates, or who knowingly classify cotton improperly, and persons who knowingly influence, or attempt to influence improperly the classifiers licensed under the Act.

CONCLUSION.

The membership of the International Federation of Master Cotton Spinners has an undoubted interest in this whole matter as great users of American cotton. If the spinners in Europe, the merchants in Manchester and Liverpool, exporters and interior merchants in the United States, and the farmers of the American cotton belt can speak in identical terms so that each grade name will mean the same everywhere, an enormous advantage will be gained promoting economy and efficiency from first to last. [*International Cotton Bulletin*, No. 3, 1923.]

COTTON RESEARCH.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

CONTROL OF COTTON ANTHRACNOSE.

The development of anthracnose can be prevented by simultaneously heating and drying cotton seed in the absence of oxygen. In the presence of oxygen the fats and proteins of the seed appear to be oxidised so that the embryo is killed. The oxygen can be removed by evacuation or by introducing nitrogen into the drying tubes. After 26 hours heating of the seed in evacuated glass tubes in the presence of calcium chloride at 100°F. all fungi are destroyed and the germinating power of the seed is increased. [*Chem. Zentr.*, 1923, 1, 1608; from *Amer. Fertilizer*, 1923, 58, 32-34. G. F. LIPSCOMB and G. L. CORLEY.]

CLEANING OF COTTON.

Since dry cotton cleans better than wet cotton, equal cleaning can be attained with less damaging of the staple by airing and artificially drying cotton before feeding it to the openers, and subsequently lessening the beater action. The cotton could be mixed and stored for some days in a fireproof room provided with ventilators and radiators. The cotton must, however, be thoroughly conditioned before reaching the cards and the adoption of the above drying method would probably cause the use of atomisers for spraying moisture directly on to the lap to become more general. It is stated that an oil emulsion sprayed upon cotton will aid materially in the carding and also reduce the amount of fly. The practice of spraying soap solution, at present restricted to short staple and waste mills, to hold together the short fibres in the lap and prevent fly, is capable of development in the ordinary cotton industry. [*Cotton*, 1923, 87, 659-660. R. B. SMITH.]

COTTONISING HEMP.

The possibility of augmenting the supply of raw material, or replacing part of the raw cotton employed in Germany by cottonised bast fibre is discussed and shown to be possible from an economic point of view if hemp is employed and the cultivation is carried on in co-operation with the cottonising process. Hemp can be cultivated on low-lying moorland of which approximately one million hectares are available in Germany. The mechanical and chemical processes of treating bast fibres, now employed, furnish a product very similar to cotton and capable of being spun on cotton spinning machinery. [*Z. angew. Chem.*, 1923, **36**, 129-130. P. WAENTIG.]

FORMATION OF CELL WALL.

As a result of a study of cotton and *Tradescantia* hairs, the author develops a theory of cell wall formation, based on the deposition of preformed particles of wall substances by the cytoplasm. Actual observations lead to the deduction that the cytoplasm rotates in a double spiral band, adjacent bands moving in opposite directions; this accounts for the striations, which occur along the stream lines, and the double lines of weakness at the junction of the bands. [*Jour. Text. Inst.*, 1923, **14**, T. 85-113. H. J. DENHAM.]

MICROSCOPY OF COTTON HAIR.

In connection with a study of the morphology of the cotton hair, details are given of the methods and reagents used in mounting the material. The interpretation of the microscopic images, under ordinary and polarised light, is also discussed and directions are given for detecting and obviating various optical falsities. [*Jour. Text. Inst.*, 1923, **14**, T. 85-113. H. J. DENHAM.]

MORPHOLOGY OF COTTON HAIR.

A study has been made of the various structures occurring in the wall of the cotton hair, and the origin of these structures

is discussed, partly with the aid of analogous material, such as *Tradescantia* hairs. The conclusions drawn are as follows:—

(1) Striations occur in all parts of the hair and in all layers of the wall; the direction followed is not always the same in superimposed layers. (2) Convolutions follow the direction of the primary striations. They are caused by a double spiral line of weakness in the hair, and are of four types; normal, movable, preformed, and suppressed. (3) Slip planes, like those observed in strained timber and in bast fibres, occur widely in cotton, and also lines of failure due to buckling. They are primarily due to internal stresses in the boll, and sometimes occur in a spiral plane or in elongated forms known as “beaded pits.” (4) Some abnormalities in the cotton hair are due to the tendency of the hair to fill up all available boll space, limitations imposed by the size of the boll having a great influence on hair conformation. (5) No true pits exist in the wall, but areas of special permeability occur in a double spiral pattern. [*Jour. Text. Inst.*, 1923, **14**, T. 85-113. H. J. DENHAM.]

• STRUCTURE OF COTTON HAIR.

Observations have been made on Sakel cotton, grown in a green-house, in the course of which three new methods were employed, namely, (1) observation in elliptically polarised light, (2) preparation of longitudinal sections, (3) development in the primary wall of a definite structure and of a substance reacting to cellulose stains, by boiling with potassium hydroxide. The following conclusions are drawn:—(1) The direction of convolutions formed in isolated hairs is entirely determined by the spiral reversals of wall construction. (2) Certain chemical relationships are indicated by the following facts:—(a) the wall does not fall into convolutions following mere plasmolysis, but does so on drying; (b) this loss of constructional water is irreversible; (c) the structural relationships to polarised light are but little affected by strong alkalis, but are readily abolished by acids. (3) Two cases of mirror image structure appear to exist in the hair wall though these do not necessarily imply stereo-isomerism. In both cases the surface of reversal is

at a normal to the current direction of growth : (a) the secondary wall visible structure is shown to form mirror images on either side of a reversal point ; (b) the primary wall structure is conjectured to consist of two concentric cylindrical layers (probably molecular) whose structures are mirror images. At reversal points these layers are presumed to change places. (4) The structures formerly termed "slow spirals" are designated "slip spirals" : (a) the slip spirals are now shown to be invariably opposed to the pit spirals, thus resembling cleavage planes ; (b) the single slip spiral of the cotton secondary wall is considered equivalent to the twinned slip spirals of wood cells, and it exists as a twin in the primary wall. (5) The number of structure reversals in the wall of one hair cell fluctuates round a mode in the neighbourhood of 30, indicating that a tendency to the formation of one complete reversal daily during growth in length is still a possible view : (a) the full number is present as soon as secondary thickening begins ; (b) no means for demonstrating the presumed reversals in the primary wall have yet been devised. (6) Two helical spirals have been found :—(a) one is seen in both primary and secondary wall (slip spiral) at 70° ; it is twinned right- and left-handed in the former only ; (b) the other in the secondary wall, called the pit spiral, appears to have a constructional angle of 29° , subsequently reduced by torsion during growth in thickness. (7) The tangents of these angles happen to stand almost exactly in the ratio of 4 : 1 which suggests polymerisation, as does also the change in number of extinction positions. (8) Some tentative speculations as to its ultimate structure are made in terms of a space-lattice hypothesis. [*Proc. Roy. Soc.*, 1923, **95B**, 72–89. W. L. BALLS.]

STRUCTURE OF COTTON HAIR WALL.

The spiro-fibrillar structure of the cotton cell-wall suggests that the wall is a sponge-like structure with (in the dry state) free air spaces therein. The specific gravity of cotton cellulose cell-walls, in their natural condition, is about 0.90 to 1.10. [*Proc. Roy. Soc.*, 1923, **95B**, 72. W. L. BALLS.]

MATHEMATICAL CONTROL OF FIELD PLOTS.

The author discusses the probable error concept in the interpretation of field experiments and emphasizes its importance. The formulæ in general use for the calculation of probable errors are explained and a new method, as well as a different way of using Bessel's and Peter's methods, is suggested. [*Jour. Amer. Soc. Agronomy*, 1923, **15**, 217-224. H. H. LOVE.]

Discussing some limitations in the application of the method of least squares to field experiments the author issues a warning against a too strict insistence on the application of the probable error and other constants. [*Jour. Amer. Soc. Agronomy*, 1923, **15**, 225-239. S. C. SALMON.]

**PERSONAL NOTES, APPOINTMENTS AND TRANSFERS,
MEETINGS AND CONFERENCES, ETC.**

IN the retirement of RAO BAHADUR K. RANGACHARI, M.A., L.T., I.A.S., on 3rd September, 1923, the Madras Department of Agriculture has lost a Botanist of distinction.

After a brilliant educational career, Mr. Rangachari joined the Madras Museum where he made valuable additions to the specimens and improved their arrangement. The best part of his activities, however, began on his appointment as Lecturing Botanist at the newly opened Coimbatore Agricultural College. The facilities afforded by the well-equipped laboratories at the college brought out the best in him and helped him in producing the first Text Book on Botany for Indian students. It bears testimony to his wide knowledge and indefatigable industry and is being used as a Text Book in various arts and professional colleges. Last year he made another addition to the meagre literature on Indian botany by publishing "A Handbook of Some South Indian Grasses."

In recognition of his valuable work Mr. Rangachari was created a Rao Bahadur in 1913 and elected to preside over the Botanical Section of the Indian Science Congress in 1917. He acted as President of the Indian Botanical Society in 1922.

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ON return from leave, Mr. S. MILLIGAN, M.A., B.Sc., resumed the duties of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, on 2nd November, 1923.

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THE services of Mr. M. J. BRETT, M.R.C.V.S., Imperial Bacteriological Laboratory, Muktesar, have been placed at the disposal of the Government of the Punjab.

MR. K. McLEAN, B.Sc., Offg. Fibre Expert to the Government of Bengal, has been granted leave for five weeks from 1st December, 1923, Mr. N. C. Bose officiating.

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COLONEL A. SMITH, F.R.C.V.S., Principal, Veterinary College, Bengal, has been permitted to retire from 25th December, 1923.

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MR. M. H. SOWERBY, M.R.C.V.S., Offg. Principal, Bombay Veterinary College, has been granted, from 1st August, 1924, combined leave for 15 months with permission to prefix the college vacation.

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MR. G. CLARKE, F.I.C., F.C.S., has been appointed to officiate as Director of Agriculture, United Provinces, *vice* Dr. H. M. Leake on deputation to the Soudan.

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THE services of Dr. H. E. ANNETT, Opium Research Chemist, United Provinces, have been replaced at the disposal of the Government of India with effect from the expiry of leave granted to him.

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MR. P. K. DEY, M.Sc., Plant Pathologist to Government, United Provinces, has been granted leave for three months from 12th November, 1923, Mr. S. D. Joshi officiating.

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LALA H. N. BATHAM, M.A., has been appointed to officiate as Agricultural Chemist to Government, United Provinces, *vice* Mr. G. Clarke on other duty.

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BABU SIRISH CHANDRA BANERJI has been appointed to officiate as Assistant Agricultural Chemist, United Provinces, *vice* Lala H. N. Batham on other duty.

KHAN SAHEB MAHOMAD NAIB HUSSAIN has been appointed to officiate as Deputy Director of Agriculture, Rohilkhand Circle, United Provinces.

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ON return from leave COLONEL G. K. WALKER, C.I.E., O.B.E., F.R.C.V.S., resumed charge of his duties as Principal of the Punjab Veterinary College, Lahore, on 1st October, 1923.

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ON return from leave CAPTAIN E. SEWELL, M.C., M.R.C.V.S., resumed charge of his duties as Professor of Hygiene in the Punjab Veterinary College, Lahore, on 1st October, 1923.

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MR. J. W. GRANT, M.A., B.Sc., Deputy Director of Agriculture, Burma, has been posted to the charge of the Tenasserim Circle with headquarters at Moulmein from 1st December, 1923.

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MR. T. D. STOCK, B.Sc., D.I.C., A.R.C.S., Deputy Director of Agriculture, Myingyan Circle, Burma, has been nominated to be a member of the Indian Central Cotton Committee, Bombay, *vice* Mr. L. Lord.

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ON reversion from the appointment of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, Dr. D. CLOUSTON, C.I.E., has been reappointed Director of Agriculture, Central Provinces.

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ON relief by Dr. D. Clouston, Mr. F. J. PLYMEN, A.C.G.I., has reverted to his substantive appointment of Agricultural Chemist, Central Provinces.

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RAI BAHADUR KANAK LAL BARUA, B.L., has been appointed Director of Agriculture, Assam, in addition to his own duties as Director of Industries and Registrar, Co-operative Credit Societies, from 11th October, 1923.

Reviews

Insecticides and Fungicides ; Spraying and Dusting Equipment. A Laboratory Manual with Supplementary Text Material. By O. G. ANDERSON, Professor of Horticulture, Purdue University, and F. C. Roth, Institute in Horticulture, Purdue University. Pp. xvi + 350 + 71 figs. (New York : John Wiley & Sons, Inc. ; London : Chapman and Hall.) Price, 15s. net.

THIS book is an excellent manual of the preparation and application of the various solutions and machines used to protect plants against pests and diseases, a subject on which a concise and modern compendium will prove very welcome to plant pathologists.

The first half of the book is written in the form of a series of laboratory exercises. Each exercise contains directions for the preparation and use of an insecticide or fungicide followed by a few questions to test the student's knowledge. The sources from which the information necessary to answer the questions may be best obtained are sometimes indicated by references to current literature, by no means the least valuable feature of this work. Some fifty exercises in the first half of the book are taken up in this manner and the remaining 25 deal chiefly with fumigation, dusting and the various types of spraying machinery. This section of the book should prove of utility both to those engaged in instructional work in colleges and technical institutes and to growers and others engaged in practical and commercial phases of the horticultural industry. The authors have wisely eschewed the complex chemistry of the various spraying solutions, and the practical man will not find himself bewildered by formulæ and scientific information which he cannot with advantage assimilate.

The second half of the book contains chapters on the control of insect and fungal diseases and on modern types of spraying and dusting machinery.

The chapter on fungal diseases has been contributed by Dr. Max W. Gardner. This author groups the method of control of plant diseases under five headings: (1) Exclusion, (2) Extermination, (3) Inhibition, (4) Protection, (5) Disease Resistance.

Exclusion is carried out in most civilized countries by regulations which prohibit and restrict the importation of living plants from foreign countries. The author points out how chestnut blight and white pine blister rust entered the United States with foreign stock and how the potato wart disease entered with imported seed tubers. In this country many will be familiar with the regulations designed to prevent the introduction of the latter disease into India.

As examples of the control of fungal diseases by the total extermination of the parasite the author quotes the citrus canker campaign in Florida, soil disinfection, the control of smut diseases by seed steeping and the control of powdery mildews on gooseberry and roses, and of peach leaf curl by spraying. Except in the case of the steam sterilization of the soil of small seed beds it appears doubtful to the reviewer whether absolute extermination of a parasite can ever be secured, although quite satisfactory control of a disease may be obtained. Thus in India complete control of peach leaf curl in the North-West Frontier Province is obtained on those orchards which have adopted dormant spraying with lime sulphur.

The control of fungal diseases by inhibition implies the adoption of some agricultural practice which acts adversely to the success of the parasite without appreciably affecting the host. Thus, in addition to the ordinary sanitary precautions which fall under this head, heteroecious parasites may be controlled by the eradication of the alternative host, e.g., stem rust of wheat and apple rust. In India, however, the wheat rust problem could scarcely be solved on these lines. Alterations in the soil reaction by special manuring may also give control of a parasite. Lining the soil against cabbage club root and the application of sulphur against potato scab are well known, and, in India, manuring with potash has been found to lessen the incidence of stem rot in jute.

By protection is meant the application of a poisonous substance to the exterior of the plant before it has become infected. This

is usually carried out by spraying or dusting with a fungicide. In India the crops which are sprayed are chiefly tea, fruit orchards, and other valuable crops, such as areca-nuts. Dusting has not yet been carried out on an appreciable scale in this country and indeed the relative merit of dusting and spraying is yet a debated question.

The control of a disease by the introduction of a variety of the host which is immune to the attack of the parasite is familiar to all agriculturists—the wheat crop perhaps furnishing the best example.

The chapter on the control of plant diseases is followed by several others devoted to a description of modern spraying and dusting machinery. As the authors truly remark, “if a spraying machine built ten years ago could be exhibited and compared with the latest model by an expert, the improvements and changes would be even more numerous and impressive than a similar comparison of automobiles.” This part of the book is of great interest both for the number and types of the most modern machines described and illustrated and as a revelation to workers in other countries of the extent to which high powered spraying is practised in the United States of America. The machines described and figured range from a Hand Atomizer to a 5-ton motor truck working at a pressure of 1,000 lb. The book concludes with two useful chapters on dusting and the operation of the gas engine.

In a subject which is developing and changing as rapidly as plant pathology it is impossible for any work to remain for long the last word on fungicides and spraying. The authors, however, are to be congratulated in that, at the present moment, they have succeeded in collecting and arranging in an accessible form the vast mass of information scattered through the scientific and technical journals of plant pathology, agriculture and horticulture. [F. J. F. S.]

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Manual of Dairy Farming.—By B. K. GHARE, College of Agriculture, Cawnpore.

MR. GHARE has shown considerable care and some knowledge of Indian conditions in compiling this work which deals briefly with soils, manures, cultivation ; housing, feeding and management

of cattle ; milk production, dairy products, tests for dairy products and the principles of cattle breeding. The arrangement of the book would be improved if Part IV—Cattle Breeding—followed or preceded Part II—Cattle Management. The book is largely a compilation of what has been written by various writers concerning European, American, and Indian dairying, and does not attempt to set forth results of original work in the direction of dairy research done by the writer in India, but all the same the writer shows a genuine appreciation of dairy conditions in India and the book is certainly a valuable addition to the scanty literature available concerning the dairy industry in this country.

The general principles applicable to Indian dairying laid down in the book are sound, and well and clearly stated, but the figures given as to the average yields, periods of lactation, etc., of Indian breeds of dairy cattle cannot be accepted as correct. They evidently refer to those of specially selected animals or herds, and it is a practical impossibility to-day to go into the market and purchase any reasonable number of either Gir, Mewati or Montgomery cows which would give the yields of milk per lactation quoted by Mr. Ghare, and it would be a very difficult matter and take a very long time to obtain in commercial quantities either Sindi cows, Delhi, Jafferabadi or Surti buffaloes which would come up to the standard of milk yield given in this book:

The description of various Indian dairy breeds given, although brief, is concise and correct, and, taken on the whole, the book can be recommended as a suitable text-book for agricultural students, and for all interested in the dairy industry in India. [W. S.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. Heredity in Poultry, by R. C. Punnett. Pp. xi+204+12 plates. (London: Macmillan & Co.) Price. 10s. net.
2. Botany: Principles and Problems, by E. W. Sinnott. (London: McGraw Hill Publishing Co.) Price, 15s.
3. Cotton and the Cotton Market, by W. Hustace Hubbard. Pp. xii+503. (London: D. Appleton & Co.) Price, 16s. net.
4. Oleaginous Products and Vegetable Oils: Production and Trade. Pp. xxxiv+511. (Rome: International Institute of Agriculture.)
5. Methods of Seed Analysis, by C. B. Saunders. Pp. 15. (Cambridge: National Institute of Agricultural Botany.) Price, 1s.
6. The Cultivation of Sugarcane in Java, by R. A. Quintus. Pp. xii+168. Illustrated. (London: Norman Rodger.) Price, 12s. net.
7. Researches on Fungi, by Prof. A. H. Reginald Buller. Vol. 2: Further investigations upon the production and liberation of spores in Hymenomyces. Pp. xii+492. (London: Longmans, Green & Co.) Price, 25s.
8. The Story of the Maize Plant, by P. Weatherwax. Pp. xv+247. (London: Cambridge University Press.) Price, 1.75 dollars.
9. Commercial Poultry Raising, by H. A. Roberts. Pp. 607. (London: Chapman and Hall.) Price, 15s. net.
10. The Foundations of Agricultural Economics, by J. A. Venn. Pp. xv+397. (Cambridge: At the University Press.) Price, 16s. net.

11. Farm Management, by W. J. Spillman. Pp. 500. (New York : Orange Judd Publishing Company, Inc.) Price, 3 dollars.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Bulletins.

1. The Improvement of Fodder and Forage in India (Papers read before a Joint Meeting of the Sections of Agriculture and Botany, Indian Science Congress, Lucknow, 1923), edited by Gabrielle L. C. Howard, M.A. (Pusa Bulletin 150.) Price, As. 6.
2. A Method for the accurate determination of Carbonic Acid present as Carbonate in Soils, by Phani Blusan Sanyal, M.Sc. (Pusa Bulletin 151.) Price, As. 2.

Report.

3. Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and Secretary, Sugar Bureau), for the year 1922-23. Price, R. 1.

